CALFED

TECHNICAL REPORT
ENVIRONMENTAL CONSEQUENCES

FISHERIES & AQUATIC RESOURCES

DRAFT

March 1998

CALFED
BAY-DELTA
PROGRAM

C-008068

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CALFED	CALFED Bay-Delta Program
CCWD	Contra Costa Water District
CEQA	California Environmental Quality Act
cfs	cubic foot per second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DCC	Delta Cross Channel
DDE	dichlorodiphenyldicholorethylene
DDT	dichlorodiphenyltricholoroethane
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
M&I	municipal and industrial
MWD	Metropolitan Water District
NMFS	National Marine Fisheries Service
ppt	parts per thousand
Reclamation	U.S. Bureau of Reclamation
SD	standard deviation
SRA	shaded riverine aquatic
SWP	State Water Project
TAF	thousand acre-feet
USFWS	U.S. Fish and Wildlife Service

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FISHERIES & AQUATIC RESOURCES

INTRODUCTION

This technical report discusses impacts on fisheries and aquatic resources associated with implementing the CALFED Bay-Delta Program (CALFED).

The impact assessment for fisheries and the aquatic ecosystem is based on available information. Because of the uncertain results of actions affecting the ecosystem, CALFED actions will be implemented through adaptive management. Adaptive management includes identification of indicators of ecosystem health, phased implementation of substantial project actions, comprehensive monitoring of the indicators, and a commitment to remedial actions necessary to avoid, minimize, or mitigate immediate and future adverse impacts of project actions on ecosystem health. Adaptive management will help achieve the intent of the CALFED Bay-Delta Program and the major ecosystem-quality objectives.

CALFED actions could affect key processes that contribute to the health of the Bay-Delta river system. These processes are discussed further under "Assessment Methods" and include:

- Flow,
- Water temperature,
- Sediment and nutrient input and movement,
- Contaminant input and movement, and
- Productivity.

Physical components of the Bay-Delta river system could be affected by surface and subsurface features, including removing or constructing structures and facilities, converting land uses, and restoration activities.

ASSESSMENT METHODS

In June 1996, CALFED began the selection of programmatic impact assessment methods for the fisheries and aquatic ecosystem section of the Programmatic Environmental Impact Statement/Environmental Impact Report (EIS/EIR). A team of agency and stakeholder fishery experts was invited to participate in the process.

In response to suggestions by participants in the assessment process during the team meetings and by written comments, the overall method for assessing programmatic impacts was expanded to address impacts at a broad ecosystem level as well as at a species level. The most important and consistently restated concern is that an evaluation of the alternatives should be based on known and defensible relationships. The assessment methods presented reflect efforts to address this concern.

Overview

The CALFED alternatives include the Ecosystem Restoration, Water Quality, Water Use Efficiency, and Levee System Integrity programs and Configurations in conveyance and storage components. The actions included in the programs and components for each alternative are described in Phase II Alternatives Descriptions. The actions fall into four general groups: flow-related actions, structure-related actions, habitat-related actions, and species-management actions. Flow-related actions include changes in reservoir operations and diversions. Structure-related actions include relocation and consolidation of diversions, construction and operation of barriers, fish screen construction and improvements, and operation of multilevel release structures to provide for water temperature needs. Habitat-related actions will improve water quality and restore habitat. Species-management actions address fish harvest regulation, hatchery production, removal of predators, and restrictions on introduction of non-native species.

Environmental variables affected by CALFED actions include physical, chemical, and biological features of the aquatic ecosystem (definitions are provided in the Supplement). Changes to the environmental variables attributable to CALFED actions are described using qualitative, measured, and modeled data. Qualitative data include general descriptions of the effects of CALFED actions on the variables. Measured data, such as floodplain acreage or river length, are available for some variables. Modeled data include simulated flow, reservoir storage, diversion, and other variables under the conditions in each alternative.

Modeled data include preliminary operations studies (CALFED 1997a) and Delta simulation model studies (CALFED 1997b). None of the studies address all CALFED alternatives or all elements included in the alternatives. Additional operations and Delta simulation model studies are ongoing.

Flows, diversions, and reservoir operations were simulated on a monthly timestep for the Sacramento-San Joaquin River system. The DWRSIM studies used in the assessment of alternatives include: 469 (existing conditions), 516 (No Action Alternative), 518 (Alternatives 1A and 1B), 528 (Alternative 2A), 529 (Alternative 3A), 530 (Alternative 2D), 531 (Alternative 1C), 532 (Alternatives 2B and 2E), 533 (Alternatives 3B and 3H), and 534 (Alternatives 3E and 3I). DWRDSM studies provided simulated flow in specific Delta channels and mass tracking information. DWRDSM studies used 16 years of hydrology from DWRSIM study 472B and focused on change in Delta structure and diversion location under Alternatives 1A, 1C, 2B, 2D, 2E, and 3E.

The methods for assessing impacts of CALFED actions on the aquatic ecosystem are summarized in Figure 1. In an effort to capture the "big picture," beneficial and adverse impacts of CALFED alternatives were assessed at the ecosystem level by evaluating changes in functional and structural characteristics; however, the needs of individual species cannot be ignored, and effects of changes in environmental variables on species-specific needs also were assessed.

The assessment relationships that follow generally indicate beneficial impacts. For most relationships, the opposite action or condition would result in adverse impacts.

Definitions of environmental variables are contained in the Supplement to this report.

Ecosystem-Level Analysis

The ecosystem-level analysis focuses on change in functional and structural characteristics of the Bay-Delta river system. Under the ecosystem approach, CALFED actions were considered beneficial if structural and functional characteristics of the aquatic ecosystem would be restored. Restoration, however, is not a return to conditions preceding human disturbance. The existing ecological landscape includes functional and structural characteristics that preclude return of the system to predisturbance conditions, including characteristics that provide existing and future social and economic values. Changes in structural and functional characteristics were considered beneficial if the resulting ecosystem would emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs (National Research Council 1992).

Information and time available for this impact assessment do not allow for evaluation of the ecosystem as a whole; therefore, functional and structural characteristics were selected to provide a measure of the change in the ecosystem under CALFED alternatives. Selection of the characteristics was based on:

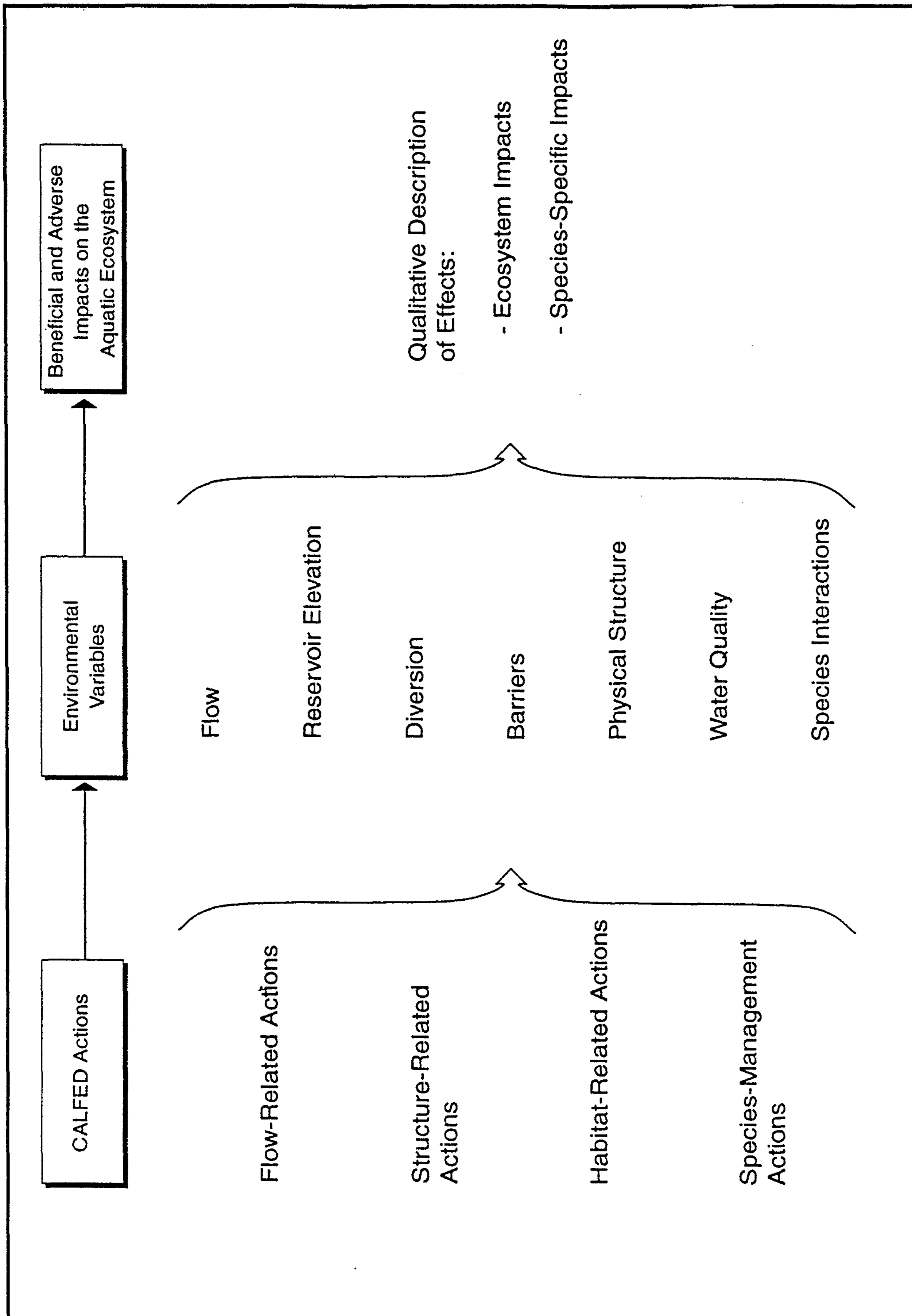

Figure 1. Linkage of CALFED Actions to Beneficial and Adverse Impacts

- Sensitivity to change in environmental variables that enables at least a qualitative comparison of the alternatives at a programmatic level of analysis,

- Availability of supporting data, including current and historical data or professional judgement, and

- Fair and consistent applicability to all alternatives.

FUNCTIONAL CHARACTERISTICS

Functional characteristics are the processes that contribute to the development and maintenance of the Bay-Delta river system (Levy et al. 1996). Ecosystem processes act directly, indirectly, or in combination to shape and form the ecosystem. Functional characteristics included in the programmatic impact assessment are flow; water temperature (heat transfer and storage); sediment, contaminant, and nutrient input and movement; and productivity.

FLOW

Flow affects a multitude of physical, chemical, and biological processes that operate in stream and estuarine channels, and is a primary driving force in the riverine ecosystem (Richter et al. 1997). Restoration of basic hydrologic features reactivates and maintains ecological processes and structures that sustain healthy fish, wildlife, and plant populations.

Beneficial impacts on flow-related processes include:

- Flow variability that approximates the natural seasonal flow variability, including effects of Delta outflow on natural seasonal variability in salinity distribution; and

- Flow conditions in Delta channels, including net and tidal flow effects, that emulate natural channel flow conditions.

Change in structural characteristics of the ecosystem will alter the potential benefit of flow changes. If, in addition to emulating the unimpaired hydrography, the natural structure of the river or Delta channels and associated floodplain is restored, the beneficial impacts on flow processes would be substantially increased.

FLOW VARIABILITY

Maintaining native aquatic biodiversity and ecosystem integrity depends on supporting and restoring some semblance of natural flow variability (Richter et al. 1997). Flow in the Bay-Delta river system is highly variable, attributable primarily to variable meteorology. During drier periods, reservoir operations and diversions may substantially alter flow relative to natural conditions. Restoration of a semblance of natural flow variability improves ecological functions in the Bay-Delta river system to support sustainable populations of diverse and valuable plant and animal species.

At the ecosystem level, the extent to which the CALFED alternatives affect natural flow variability is determined through evaluation of flow magnitude, timing, duration, frequency, and rates of change (Richter et al. 1997). Relative to existing conditions, impacts of changes in river flow, Delta inflow, and Delta outflow variability that more closely emulate the natural condition are considered beneficial. The unimpaired condition is used to develop target ranges used in this impact assessment because ecological and statistical support cannot yet be formulated into target flow ranges required to meet the ecosystem management objectives of CALFED. Monitoring and research programs that will be implemented as part of CALFED are expected to identify a more appropriate basis for adaptive flow management, taking into consideration the existing ecosystem structure and specific chemical, physical, and biological processes.

The assessment of change in flow magnitude, timing, duration, frequency, and rates of change uses the hydrological parameters shown in Table 1. The Sacramento-San Joaquin River system is simulated on a monthly time step, including the simulations of operations and flows (CALFED 1997a, 1997b); consequently, all of the parameters in Table 1 are calculated

Flow Statistics Group	Regime Characteristics	Hydrological Parameters
Magnitude of monthly water conditions	Magnitude Timing	Mean monthly flow
Magnitude and duration of annual extreme water conditions	Magnitude Duration	Mean annual minimum monthly flow Mean annual maximum monthly flow Mean annual minimum 3-month average flow Mean annual maximum 3-month average flow
Timing of annual extreme water conditions	Timing	Month of each annual minimum flow Month of each annual maximum flow
Frequency of high and low pulses	Frequency	Number of low pulses each year Number of high pulses each year
Rate and frequency of flow change[a]	Rates of change Frequency of change	Mean of all positive differences between consecutive monthly values Mean of all negative differences between consecutive monthly values Number of rises Number of falls

NOTE:

[a] The analysis of rate and frequency of flow change requires daily information or a shorter timestep. Daily information is not available at a programmatic level of analysis.

SOURCE:
Modified from Richter et al. 1997.

Table 1. Summary of Hydrological Parameters Used in the Assessment of Flow-Related Impacts

for mean monthly flow data, although daily or shorter time periods may need to be considered in development of detailed adaptive flow-management needs.

Given the absence of ecological information relative to flow needs in the Sacramento-San Joaquin River system, the natural variation of the hydrological regime and associated characteristics of timing, duration, frequency, and rate of change are assumed necessary to sustain the biodiversity and integrity of the aquatic ecosystem (Richter et al. 1997). Target values for the hydrological parameters shown in Table 1 are calculated for unimpaired flow conditions. The mean value plus and minus one standard deviation describes the target range for each hydrological parameter (shown for

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unimpaired Delta outflow in Table 2). For those parameters where a skewed distribution results in a standard deviation that exceeds the minimum or maximum value, the unimpaired minimum or maximum value is used as the lower or upper target range boundary.

Under unimpaired conditions, some of the calculated values fall outside the target range (see "frequency of nonattainment" in Table 2). The frequency of nonattainment of the target range for the unimpaired conditions is compared to the frequency of nonattainment of the target range for the CALFED alternatives. If the frequency of nonattainment of the target range for an action alternative is greater (i.e., 7%) than the frequency of nonattainment for the No-Action Alternative and for the unimpaired condition, an adverse impact is identified. An example assessment comparison is shown for historical Delta outflow conditions relative to unimpaired conditions (Table 3).

In addition to flow variability discussed above, variability in estuarine salinity distribution is evaluated. Natural variability in salinity distribution is important to maintaining a healthy and diverse estuarine ecosystem. Salinity affects a multitude of ecological processes, including those affecting the distribution and abundance of wetland vegetation and other aquatic organisms. The Bay-Delta ecosystem is characterized by short-term, seasonal, annual, and long-term variability in ocean salinity incursion (San Francisco Estuary Project 1993). Delta outflow and Delta channel structure, relative to effects on tidal conditions, are the primary determinants of salinity distribution. Change in Delta outflow and structure and the resulting variability in X2 (i.e., tidal day averaged location of about 2 ppt bottom salinity) are calculated for all alternatives. As described above for flow, if the frequency of nonattainment of the X2 target range for an action alternative is greater than the frequency of nonattainment for the No-Action Alternative and for the unimpaired condition, an adverse impact is identified.

DELTA CHANNEL FLOW

In most Delta locations, tidal flow dominates Delta hydraulics and net flow is a relatively minor component (CALFED 1997b); however, location and volume of net channel inflows and outflows determine the distribution of water and associated components throughout the Delta. Movement through the Delta from specific locations is affected by multiple net flows and flow divisions (Table 4). Additionally, water and associated components are removed from Delta channels by Delta island diversion and State Water Project (SWP) and Central Valley Project (CVP) export. Rate of movement through specific channel reaches is also affected by channel structure and volume (e.g., island flooding can change the rate of movement under similar net flow conditions). Net channel flow and diversion and export rates provide some indication of the movement of water and associated components. Mass tracking studies provide a more accurate measure of water movement within and through the Delta channels.

Evaluation of impacts on flow conditions in Delta channels is based on the results of DWRDSM (i.e., Delta hydraulic simulation model) flow and mass tracking studies (CALFED 1997b). The results of the mass tracking studies are displayed as "mass fate" (i.e., the fate of a mass introduced at discrete locations in the Delta). Mass fate provides an indication of residence time in the Delta channels, movement of water out of the Delta, and entrainment in Delta diversions and exports. Additionally, mass fate reflects the effects of change in structural characteristics on tidal and net flow conditions, including effects of removal or closure of barriers, dredging, and flooding of existing Delta islands.

	Mean	SD	Minimum	Maximum	Target Range Low	Target Range High	Rate of Nonattainment (%) Below	Rate of Nonattainment (%) Above
Monthly magnitude (TAF)								
October	596	381	315	3,289	315	977	0	8
November	1,185	1,207	338	6,151	338	2,392	0	10
December	2,424	2,594	386	12,861	386	5,018	0	11
January	3,339	2,993	404	14,518	404	6,332	0	15
February	3,962	2,947	534	16,847	1,016	6,909	7	18
March	4,154	2,583	626	15,828	1,571	6,737	11	17
April	4,119	1,998	769	11,259	2,121	6,117	13	14
May	4,157	1,994	1,004	8,852	2,164	6,151	15	14
June	2,587	1,564	476	8,321	1,022	4,151	14	15
July	1,051	655	323	4,095	396	1,705	4	17
August	542	206	278	1,571	336	748	7	15
September	465	138	269	961	327	603	13	11
Mean annual extremes (TAF)								
Annual minimum month	432	111	269	961	320	543	13	14
Annual minimum 3 months	511	161	290	1,174	350	672	11	7
Annual maximum month	6,230	3,442	1,004	16,847	2,788	9,671	17	14
Annual maximum 3 months	4,769	2,319	862	10,834	2,450	7,088	15	17
Timing of annual extremes								
Month of minimum	9	1	7	11	8	10	13	28
Month of maximum	3	2	12	6	1	5	18	21
Frequency of pulses								
Annual low pulse count	3	2	0	8	1	5	17	18
Annual high pulse count	3	2	0	8	1	5	24	18
Monthly flow change								
Annual fall count	7	1	4	9	5	8	14	19
Annual rise count	5	1	3	8	4	7	19	14
Annual fall (TAF)	1,106	679	122	3,360	427	1,785	14	13
Annual rise (TAF)	1,356	835	113	3,786	521	2,190	14	17

NOTES:

SD = Standard deviation.
TAF = Thousand acre-feet.

Table 2. Example Calculation of Target Flow Ranges: Unimpaired Delta Outflow

	Mean	SD	Minimum	Maximum	Rate of Nonattainment of Target Range (%)			
					Historical		Unimpaired	
					Below	Above	Below	Above
Monthly magnitude (TAF)								
October	609	418	128	2,638	22	12	0	8
November	973	806	217	4,412	12	5	0	10
December	2,037	2,053	259	9,559	3	12	0	11
January	3,054	2,760	224	11,875	6	12	0	15
February	3,394	2,737	175	11,408	18	12	7	18
March	3,278	2,791	189	16,398	23	11	11	17
April	2,560	2,302	183	9,151	58	14	13	14
May	1,938	1,676	212	7,002	66	3	15	14
June	1,117	1,123	(13)	4,822	62	3	14	15
July	414	426	(183)	2,697	68	2	4	17
August	311	257	(121)	1,511	65	8	7	15
September	502	348	68	1,874	37	29	13	11
Mean annual extremes (TAF)								
Annual minimum month	237	222	(183)	1,413	72	8	13	14
Annual minimum 3 months	365	291	(106)	1,790	58	12	11	7
Annual maximum month	4,828	3,377	273	16,398	35	9	17	14
Annual maximum 3 months	3,695	2,527	267	11,062	45	12	15	17
Timing of annual extremes								
Month of minimum	8	1	6	11	80	14	13	28
Month of maximum	2	1	12	5	32	5	18	21
Frequency of pulses								
Annual low pulse count	5	3	0	12	14	48	17	18
Annual high pulse count	2	2	0	7	45	9	24	18
Monthly flow change								
Annual fall count	6	1	3	8	35	3	14	19
Annual rise count	6	1	4	9	5	35	19	14
Annual fall (TAF)	905	633	47	2,796	29	11	14	13
Annual rise (TAF)	873	675	26	2,558	42	8	14	17

NOTES:

SD = Standard deviation.
TAF = Thousand acre-feet.

SOURCE:
DWR 1995.

Table 3. Example Comparison of Nonattainment of Target Ranges: Historical Delta Outflow Compared with Unimpaired Delta Outflow

Origin of Water and Associated Components	Net Delta Channel Flows That Partially Control Movement and Entrainment
Sacramento River at Freeport	Sacramento River inflow
	Isolated facility diversion
	Cross-Delta flow[a]
	QWEST[b]
Sacramento River at Rio Vista	Sacramento River at Rio Vista
	QWEST
San Joaquin River at Vernalis	San Joaquin River inflow
	Head of Old River
	Old and Middle rivers
San Joaquin River at Jersey Point	QWEST
	Threemile Slough
Snodgrass Slough below the Delta Cross Channel	Cross-Delta flow
	Mokelumne River inflow
	QWEST
Old River at Rock Slough	Old and Middle rivers

NOTES:

[a] Cross-Delta flow is the sum of net flow in Georgiana Slough, the Delta Cross Channel, and any new flow diversions off the Sacramento River to the Mokelumne River channels—for example, at Hood.

[b] QWEST is net flow in the lower San Joaquin River calculated as the difference between inflow (eastside tributary inflow, San Joaquin River inflow, precipitation, and cross-Delta flow) and diversions (Delta island diversions, State Water Project and Central Valley Project exports, Contra Costa Water District diversions).

Table 4. Net Delta Channel Flows That Partially Control the Movement and Entrainment of Water and Associated Components Originating from Specific Delta Locations

Mass fate conditions are characterized by mass tracking for discrete injection points: Sacramento River at Freeport and Rio Vista, the San Joaquin River at Vernalis, Old River at Rock Slough, and Snodgrass Slough below the Delta Cross Channel. Mass fate is reported for 1- to 60-day simulations and includes the percentage remaining in the Delta, the percentage downstream of Chipps Island, and the percentage entrained in CVP and SWP exports and in-Delta island diversions.

Re-establishing historical Delta hydraulics and re-establishing the natural structure of the Delta are assumed to reactivate essential ecosystem processes, including sediment movement, nutrient recycling and movement, and productivity. Restoring a semblance of natural variability in flow conditions and mass fate contributes to improved ecological functions in the Delta to support sustainable populations of diverse and valuable plant and animal species. Changes in net flow and mass fate conditions that move toward ecosystem restoration are:

- Reduced percentage of mass entrained in Delta diversions and exports, and
- Delta channel flow that more closely approximate natural conditions, including

natural Delta residence time and movement of mass into Suisun Bay.

Reduced percentage of mass entrained in Delta diversions indicates reduced loss of Delta production, including reduced loss of nutrients, phytoplankton, and zooplankton. Benefits are also indicated for fish species, especially species with planktonic eggs and larvae (see methods for representative species discussed a the following section).

Natural Delta flow conditions have been substantially altered by structural changes to Delta channels, Delta diversions and exports, and upstream diversion and reservoir operations (i.e., effects on Delta inflow). For the purpose of this impact assessment, flow conditions assumed to represent "natural" net channel flow conditions are achieved by:

- Closer approximation of natural inflow patterns (i.e., see flow variability in the preceding section);
- Removal of barriers, levee set-back, levee removal, and other actions that increase natural channel dynamics, including erosional and depositional processes that restore channel patterns and capacity; and
- Net flow direction toward Suisun Bay.

An alternative that more closely achieves the above conditions relative to the No-Action Alternative and existing conditions is assumed to have beneficial impacts on ecosystem processes. Ecological and statistical support cannot yet be formulated into target Delta flow conditions required to meet the ecosystem restoration objectives of CALFED. Monitoring and research programs that will be implemented as part of CALFED are expected to identify a more appropriate basis for adaptive flow management, taking into consideration the existing ecosystem structure and specific chemical, physical, and biological processes in the Delta.

WATER TEMPERATURE

Water temperature affects a multitude of physical, chemical, and biological processes. At the ecosystem level, beneficial impacts generally accrue from re-establishing the natural variability in water temperature. When water temperature data is available, the extent to which the project actions affect natural water temperature variability is determined through evaluation of temperature magnitude, timing, duration, frequency, and rates of change, similar to evaluation of flow variability discussed above. Relative to existing conditions, impacts of changes in water temperature that more closely emulate the natural condition are considered beneficial.

Human-caused changes in the Bay-Delta river system, however, have resulted in major changes in short-term and seasonal water temperature variability. Given existing structural characteristics of the ecosystem and supported species and communities, emulating natural water temperature conditions may not sustain the existing or desired biodiversity or the integrity of the aquatic ecosystem. Management priorities must identify target ranges used in the evaluation of water temperature variability, based on the water temperature needs of existing or desired communities and species.

In the absence of water temperature data, implementation of actions that increase the flexibility to meet target water temperature conditions or that restore natural heat transfer and storage processes are considered beneficial. Actions that increase flexibility to meet target water temperature conditions include:

- Construction and multilevel reservoir release structures,

- Increased carry-over reservoir storage, and
- Increased volume of water dedicated for ecological flow and water temperature purposes.

Multilevel release structures improve management of the coldwater pool, allowing release of warmer water during periods of low species sensitivity or low ambient air temperature. The coldwater pool within the reservoir is conserved for use during periods of greater species sensitivity and months when river water temperatures may exceed species needs. Similarly, increased carry-over storage and increased volume of water dedicated to flow and water temperature needs may increase the coldwater pool or increase the ability to affect downstream reaches, providing water temperature within target ranges. The actions identified above are applicable to river reaches below reservoirs and would minimally affect Delta water temperature. Because of the distance from the upstream reservoirs, water temperature in the Delta is primarily driven by weather.

Actions that restore natural heat transfer and storage processes include:

- Reduction or relocation of agricultural return flows,
- Reduction or relocation of municipal and industrial (M&I) discharge of thermal waste,
- Re-establishment of natural channel structure, and
- Increased length of restored riparian or SRA communities.

Reduced return flows and reduced discharge of heated municipal and industrial effluent may reduce thermal inputs to natural channels. Restoration of riparian communities, SRA communities, and channel structure will provide shading and re-establish natural heating and cooling processes.

SEDIMENT AND NUTRIENT INPUT AND MOVEMENT

Input and movement of sediment, and associated nutrients, are important processes affecting the development and maintenance of the Bay-Delta river system. Re-establishing conditions that approximate natural sediment delivery to and movement within the system have beneficial impacts. Actions that re-establish natural sediment supply and movement include:

- Remove dams and other barriers to sediment and nutrient movement;
- Cease or limit sediment extraction, such as gravel mining and dredging;
- Re-establish natural channel structure;
- Improve watershed management;
- Restore riparian, shaded riverine, marsh, and floodplain communities;
- Implement best management practices during construction activities; and
- Establish flow patterns consistent with sediment movement dynamics required to maintain desired biological communities (see "Flow" above).

Several of the actions re-establish pathways for sediment movement. Dams retain sediment, preventing movement from the upper watershed to downstream reaches. Removal of dams would reconnect the supply of sediment to downstream reaches of rivers and the estuary. Limits on sediment extraction would also increase the supply of sediment to downstream reaches. Re-establishment of natural channel structure, including floodplain connections and river meanders, restores processes affecting movement of sediment within the main channel and from adjacent lands. Re-establishment of natural channel structure may include removal of levees, weirs, and bank protection (see "Structural Characteristics" below).

Watershed management actions may address grazing, wildfires, agriculture, and urban development. Improved watershed management and Restoration of riparian, shaded riverine, marsh, and floodplain communities would affect erosion and deposition processes, increasing sediment stability and restoring channel dynamics. Implementation of best management practices during construction activities would prevent short-term increases in sediment input that may have detrimental impacts on aquatic communities through increased sedimentation or turbidity.

Human-caused changes in the Bay-Delta river system have resulted in major changes to channel structure. Although re-establishment of natural flow patterns potentially restores natural sediment input and movement processes, natural flows through the existing system could damage existing or desired biodiversity and the integrity of the aquatic ecosystem. Establishment of flow patterns requires consideration of management priorities and concurrent actions to re-establish natural channel structure and restore riparian, floodplain, wetland, and aquatic communities.

Adding gravel substrate to river reaches below reservoirs is also assumed to have beneficial impacts. Adding sediment replaces, to some degree, the natural process of gravel recruitment now interrupted by dams.

CONTAMINANT INPUT AND MOVEMENT

Contaminants are substances that are toxic to aquatic organisms or create conditions that adversely affect aquatic organisms in the Bay-Delta river system. Contaminants include metals (e.g., mercury, copper, cadmium, and zinc); selenium; ammonia; salinity from runoff; pesticides; fertilizers; sewage; and uncharacteristically high fine sediment loading. Toxic effects may include death, reduced growth rate, and reduced fertility of individual organisms. Changes in conditions that adversely affect aquatic organisms include reduced dissolved oxygen levels in response to input of excessive nutrients from agricultural and urban runoff or sewage discharge.

Beneficial impacts on functional characteristics of the ecosystem would be achieved primarily by reducing input of contaminants. Reduced contaminant input may be achieved through:

- Development of more benign application techniques and use of less-toxic agricultural and industrial chemicals;
- Improved point ant non-point wastewater treatment prior to discharge;
- Improved watershed management; and
- Implementation of best management practices during construction activities.

Improved point and non-point wastewater treatment may include upgraded sewage treatment, construction of storm water run-off storage, and discharge to constructed wetlands prior to discharge to the Bay-Delta river system. Watershed management could reduce excessive input of fine sediment, pesticides, and other material. Watershed management actions may address grazing, wildfires, agriculture, and urban development. Implementation of best management practices during construction activities would prevent short-term discharge of contaminants and reduce the probability of contaminant spills.

In addition to reduced inputs, natural biological processing of contaminants may be increased through restoring marshes and wetlands. Reliance on natural processing of contaminants, however, must include implementation of monitoring and mitigation components. Monitoring should focus on detecting increased contaminant concentrations and the potential for aquatic organisms to accumulate, magnify, transform, and mobilize contaminants to the detriment of aquatic communities or individual organisms. The mitigation should include potential actions to reduce or eliminate input of contaminants and remove contaminants accumulated in sediment or vegetation.

Although reduced input is the primary avenue for beneficial impacts related to contaminants, actions that minimize adverse impacts may also be implemented. Adverse effects of contaminants may be minimized through:

- Avoiding discharge of contaminants during sensitive periods;
- Relocating discharges to less-sensitive areas, and
- Discharge of dilution flows.

Some species or life stages are sensitive to specific contaminants. Discharging contaminants when sensitive species are not present or relocating the discharge to areas not supporting sensitive species would minimize adverse affects. Dilution flows reduce the concentration of contaminants. Dilution flow may be achieved by increasing reservoir releases, reducing diversion, or operating barriers to direct flow along pathways receiving contaminants. Dilution flow, however, may have limited ecosystem benefits because contaminants continue to enter the ecosystem and flow for dilution may not coincide with other flow needs associated with reactivation and maintenance of ecological processes and structure (see "Flow" above).

PRODUCTIVITY

Productivity is the capacity of the aquatic ecosystem to produce a product of interest (e.g., a species population or group of species) (Warren 1971). The capacity of an ecosystem to produce a product of interest depends on basic energy and material resources, both those developed within an ecosystem and those introduced from external sources. Changes in energy and material resources inevitably leads to changes in the abundance of species and changes in ecological communities. Healthy fish, wildlife, and plant populations in the Bay-Delta river system are dependent on maintaining and improving processes affecting productivity.

The complexity and magnitude of energy and material transfer through the ecosystem has limited the description of cause and effect productivity relationships to relatively simple controlled studies. Pathways of energy and material transfer through the Bay-Delta river ecosystem may eventually be described in qualitative terms, but quantifying rates of food consumption, assimilation, respiration, growth, and production through all trophic pathways in the ecosystem is not possible. Although results will be speculative, impacts of project actions on productivity of the Bay-Delta river system warrants consideration because human activities substantially affect productivity, including changes in species abundance.

Through density-dependent relations, increase or decrease in the basic energy and material resources changes the abundance of food, affects the abundance of species, and changes production-biomass relationships. Even small changes in basic energy and material resources (e.g., input of organic material) may cause substantial changes in the capacity of the Bay-Delta river ecosystem to produce organisms, altering aquatic communities and affecting species abundance. The qualitative assessment of project actions on productivity is based on the assumption that project actions are beneficial if structural and functional characteristics of the aquatic ecosystem are restored, including reduction of human induced stresses. Actions assumed to have beneficial impacts on productivity include:

- Reduce loss of nutrients and organisms to diversions,
- Reduce input of contaminants;
- Re-establish basic hydrologic features, including flow variability and residence time (see "Flow");
- Re-establish conditions that approximate the natural sediment and nutrient delivery to the system (see "Sediment and Nutrient Input and Movement"); and
- Restore structural characteristics to approximate the natural structural characteristics of the aquatic ecosystem (see "Structural Characteristics" in the following section).

Diversions remove material from the ecosystem, affecting the capacity of the ecosystem to produce products of interest through direct reduction of both food and species abundance. Adverse impacts of diversions on productivity may be lessened through reduced diversion volume, relocation of diversions to locations outside of the range for species of interest, reoperation of diversions to avoid sensitive periods (e.g., during periods of high biomass or susceptible life stages), and installation of fish protection facilities (e.g., fish screens).

Input of contaminants may increase mortality or decrease reproduction and growth, reducing food and species abundance. Actions that reduce contaminant input are discussed under "Contaminant Input and Movement".

Re-establishing basic hydrologic features, in combination with re-establishing natural sediment and nutrient delivery and restoration of structural characteristics, moves toward natural ecosystem conditions. Variability in the levels of energy and material resources derived from within and introduced from external sources will be more consistent with variability in a natural system, potentially improving conditions for species native to the system. Increased productivity for products of interest, however, is speculative because of the complexity and magnitude of energy and material transfer through the ecosystem and potential effects of historical conditions, introduced species, and ongoing human perturbations.

STRUCTURAL CHARACTERISTICS

Structural characteristics refer to the physical components of the Bay-Delta river system and their spatial relationships to one another (Levy et al. 1996). The analysis of structural characteristics is restricted to distinct surface and subsurface features (e.g., floodplain, flooded islands, dead-end sloughs, river channels, riparian communities, tidal marsh). Re-establishment of natural structural characteristics is considered to have a beneficial impact. Actions assumed to restore or re-establish natural structural characteristics include:

- Restore area, volume, and length of surface and subsurface features of the aquatic ecosystem;
- Re-establish channel density and complexity;
- Increase the ratio of natural to protected levees and banks;

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- Increase the ratio of unconstrained river or channel reaches to reaches constrained by levees;

- Increase the length of river or Delta channels not blocked by dams and other barriers; and

- Increase the ratio of floodplain acreage subject to unconstrained flooding to floodplain acreage separated from the river by levees and weirs.

Beneficial impacts of changes in the structural characteristics described above are primarily reflected in the preceding discussions under "Functional Characteristics" and in the "Species-Specific Analysis" that follows. Structural characteristics substantially affect functional characteristics of the aquatic ecosystem, including flow, water temperature, sediment and nutrient input and movement, contaminant input and movement, and productivity.

Species-Specific Analysis

All aquatic species in the Bay-Delta system have intrinsic value as components of biological diversity. Several species in the system also have significant social and political value, including value to commercial and sport fisheries. The method for assessing the effects of CALFED actions on representative species includes integration of species-specific relationships with the ecosystem-level analysis described above. A description of the process of selecting representative species is followed by a description of relationships that were used to assess the effects of CALFED actions.

SELECTION OF REPRESENTATIVE SPECIES

Assessment of the impacts of CALFED actions on representative species provides a description of potential effects at the species level of ecosystem organization. Each species and life stage responds differently to changes in an environmental variable. A representative group of fish and invertebrate species was selected by the assessment methods team based on the importance of the species and their potential response to environmental variables affected by CALFED actions. Twenty-five species were selected to include in the analysis, 18 species of fish and seven species or groups of invertebrates. Although chinook salmon is identified as a single species in Table 5, effects on each race (fall, late-fall, winter, and spring runs) were analyzed. A species was considered important if it met any of the following criteria:

- Supports a commercial fishery,

- Supports a sport fishery,

- Is listed under the federal or state Endangered Species Acts (ESAs), is proposed for such listing, or is a species of special concern, or

- Has a potential significant and distinctive response to environmental variables affected by CALFED actions.

SPECIES-SPECIFIC RELATIONSHIPS

CALFED actions will cause changes in environmental variables, which in turn will result in beneficial or adverse impacts on representative species. Information and time available for this impact assessment do not allow for evaluation of species population responses; therefore, factors critical to species

Common Name	Scientific Name	Delta Region	Bay Region	Sacramento River Region Reservoir	Sacramento River Region River	San Joaquin River Region Reservoir	San Joaquin River Region River
Fish							
Rainbow trout	*Oncorhynchus mykiss*			X		X	
Largemouth bass	*Micropterus salmoides*	X		X		X	
White sturgeon	*Acipenser transmontanus*	X	X		X		X
Chinook salmon	*Oncorhynchus tshawytscha*	X	X		X		X
Steelhead	*Oncorhynchus mykiss*	X			X		X
Sacramento squawfish	*Ptychocheilus grandis*				X		X
American shad	*Alosa sapidissima*	X			X		X
Sacramento blackfish	*Orthodon microlepidotus*	X			X		X
Splittail	*Pogonichthys macrolepidotus*	X	X		X		X
Striped bass	*Morone saxatilis*	X	X		X		X
Smallmouth bass	*Micropterus dolomieui*				X		X
Tule perch	*Hysterocarpus traskii*	X			X		X
Delta smelt	*Hypomesus transpacificus*	X	X				
Longfin smelt	*Spirinchus thaleichthys*	X	X				
White catfish	*Ictalurus catus*	X					
Inland silverside	*Menidia audens*	X					
Pacific herring	*Clupea harengeus pallasii*		X				
Starry flounder	*Platichthys stellatus*		X				
Invertebrates							
Terrestrial invertebrates		X			X		X
Other aquatic invertebrates					X		X
Rotifers	*Rotifera*	X					
Native mysid shrimp	*Neomysis mercedis*	X	X				
Crayfish	*Pacifastacus leniusculus*	X			X		X
Asian clam	*Potamocorbula amurensis*	X	X				
Bay shrimp	*Crangon franciscorum*		X				

NOTE:

**Oncoprhynchus mykiss* that are anadromous (move from the sea into fresh water to spawn) are referred to as steelhead, while those that do not exhibit anadromly are referred to as rainbow trout.

Table 5. Species Selected for Inclusion in the Fisheries Impact Assessment

survival and reproduction were selected to provide a measure of potential species response to actions included in the CALFED alternatives. Selection of the factors was based on:

- Sensitivity to change in environmental variables that enables at least a qualitative comparison of the alternatives at a programmatic level of analysis,

- Availability of supporting data, including current and historical data or professional judgement,

- Fair and consistent applicability to all alternatives, and

- For each species, applicability in reference to geographic and monthly occurrence by life stage (see Draft Affected Environment Technical Report for Fisheries & Aquatic Resources).

Assessment relationships were grouped into eight categories: habitat, water quality, entrainment, water surface level, movement, species interaction, artificial production, and harvest. Species and life-stage needs, along with geographical and seasonal occurrence, determine application of the species-specific indicators identified below.

HABITAT RELATIONSHIPS

Physical habitat includes the resources and conditions present in an area that allows an organism to survive, grow, and reproduce, including spawning areas, rearing areas, and migration pathways (Hall et al. 1997). In the project area, habitat loss and degraded value have been major factors in the decline of many species. Providing habitat is critical to maintaining and increasing abundance and distribution of all representative species.

For the Programmatic EIS/EIR, physical habitat relationships focus primarily on habitat abundance. Habitat abundance is a measure of the area, length, or volume of specific resources used by a species. For example, the acreage of areas that include substrates, water temperature, water velocity, and other conditions required by spawning chinook salmon is a measure of habitat abundance. Increased habitat abundance is assumed to have beneficial impacts on a species (i.e., increased habitat improves survival, growth, and reproductive success). Depending on the species, actions that may increase habitat abundance include:

- Breach, setback, or remove levees and hard bank protection (e.g., rip-rap) in the Delta and along rivers;

- Increase length of river or Delta channels not blocked by dams and other barriers;

- Provide flow, water temperature, and salinity variability that more closely approximates natural conditions or meets specific needs of a species;

- Establish riparian, wetland, and aquatic plant communities;

- Add gravel to selected stream reaches; and

- Increase reservoir storage, including new and enlarged reservoirs, to provide additional habitat for reservoir species.

An increase in the area, volume, and length of habitat that results from breach, setback, or removal of levees in the Delta and along rivers and an increase in the length of river or Delta channels not blocked by dams and other barriers is assumed to provide additional habitat for representative species. The extent of benefits to individual species will depend on the location and type of restoration relative to the spawning and rearing habitat needs of each species. Restoration of natural ecosystem structure is assumed to increase habitat abundance.

Re-establishment of natural river dynamics through restoration of natural ecosystem structure and providing flow, water temperature, and salinity variability that more closely approximates natural conditions is also assumed to benefit representative species (see "Flow" discussed above under "Ecosystem-Level Analysis" for the assessment method). For some species, however, natural flow, water temperature, and salinity conditions may be detrimental to existing populations. Reservoirs have blocked access to most of the historical habitat used by chinook salmon and steelhead and existing populations are restricted to habitat downstream of the major reservoirs. Natural water temperatures in existing habitats may be detrimental or only marginally sustain viable chinook salmon and steelhead populations; therefore, the target water temperature conditions, and possibly other environmental conditions, should reflect the needs of individual species.

Gravel is added to stream channels to create and enhance spawning habitat for chinook salmon and steelhead. Increased spawning habitat is assumed to benefit chinook salmon and steelhead in the affected river. The magnitude of the benefit and the relative need for additional or enhanced habitat cannot be determined with the available information, but the level of impact may be based on the proportional change in habitat relative to existing habitat abundance.

The actions above are assumed to increase habitat abundance and benefit species of interest. Incomplete knowledge of species needs and unpredictable responses to actions, however, may adversely impact some species. Habitat in close proximity to diversions may be of minimal value because individuals or food organisms may be lost to entrainment. Habitat isolated from existing populations may not be colonized by the species of interest. Environmental conditions in affected habitats may not be consistent with a species needs (e.g., depth, velocity, salinity, substrate, cover). In addition, although habitat may be created for a species of interest, the abundance of competing or predatory species may also increase, with subsequent detrimental effects on a species population (e.g., interactions between silversides and delta smelt or effects of Asian clams on primary productivity).

Increased habitat abundance depends on developing knowledge of species needs and understanding of the project actions. Beneficial impacts of increased habitat abundance can be assured only through implementation programs that include adaptive management.

WATER QUALITY RELATIONSHIPS

Death, reduced growth, or reduced reproductive success occur when poor water quality stresses the metabolic tolerances of an organism. Water quality relationships address the effects of water temperature, contaminants, and dissolved oxygen. In the Sacramento and San Joaquin River basins, water temperature and dissolved oxygen are primarily concerns for chinook salmon and steelhead, although other species may be adversely affected by these factors (see Affected Environment Technical Report for Fisheries & Aquatic Resources). Contaminants are a concern for all species. Depending on the availability of simulated water quality data, including water temperature and contaminant concentration, relationships would be applied that reflect species response based on sensitivity and exposure to water quality changes. Beneficial impacts at the ecosystem level on sediment and contaminant input and movement are assumed to provide beneficial impacts for the representative species (see "Ecosystem-Level Analysis"). Impacts of water temperature changes on chinook salmon and steelhead will depend on temperature needs within existing and created habitat.

ENTRAINMENT RELATIONSHIPS

Water diversions result in fish mortality through entrainment, impingement on fish screens or other diversion structures, abrasion, stress as a result of handling, and increased predation. Entrainment and associated mortality is a concern for all fish species included in the impact assessment. Life stages most vulnerable to entrainment vary by species. For example, chinook salmon are most affected during fry and juvenile rearing and downstream migration. Some species are most vulnerable during the egg and larval stage. Other species, such as delta smelt, are vulnerable as larvae, juveniles, and adults because of their small size at maturity and residence near diversions.

The environmental variables considered in assessing entrainment mortality are diversion location and timing, fish screen efficiency, and predation. Actions that reduce entrainment-related losses include:

- Build new or improve existing fish screens to reduce entrainment and impingement losses,
- Relocate diversions to areas outside of the distribution of a species,
- Relocate species distribution to Suisun Bay and subsequently reduce exposure to Delta diversions,
- Reoperate diversions to avoid periods when species are present, and
- Redesign diversions and associated facilities to reduce predator habitat or remove predators from habitat associated with diversion facilities.

Most life stages of the representative species are vulnerable to entrainment mortality; however, adults of the large-bodied species, such as striped bass, chinook salmon, green and white sturgeon, and American shad are minimally affected by diversion operations and facilities.

CALFED actions to construct and improve fish screens would reduce the loss of life stages large enough to be efficiently screened; however, fish screens would provide minimal protection for planktonic eggs and larvae. American shad and striped bass spawn planktonic eggs that are small and pass through the fish screens. American shad, striped bass, delta smelt, and longfin smelt have planktonic larvae that would either pass through the screens or, because larvae are weak swimmers, would be impinged on the screen surface.

Diversion facilities provide habitat and increased feeding opportunity for predatory fish (California Department of Fish and Game 1987a, Vogel 1995). Project actions that implement programs to remove predators and change facility design to reduce prey vulnerability reduce predation on the representative species.

Shift in estuarine salinity may alter the geographic distribution of aquatic organisms. Occurrence of 2 ppt salinity upstream of Chipps Island shifts the primary distribution of larval and juvenile delta smelt and striped bass into the Delta (California Department of Fish and Game 1992a, 1992b; Herrgesell 1993). Redistributing species to Suisun Bay reduces exposure to Delta diversions and potentially reduces diversion-related mortality.

WATER SURFACE-LEVEL RELATIONSHIPS

Short-term changes in water surface levels may result in mortality by exposing nests, stranding individuals, reducing or eliminating cover, and other means. The effects of changes in water surface levels are assessed for rivers and reservoirs.

Water surface-level fluctuation in rivers is assessed for chinook salmon, steelhead, and splittail. Water surface-level fluctuation in reservoirs is assessed for largemouth bass. Chinook salmon and steelhead lay eggs in gravel nests, splittail lay eggs on flooded vegetation, and largemouth bass lay eggs in nests in relatively shallow water near the reservoir shore. Increased frequency and magnitude of short-term water surface-level fluctuation increases mortality caused by exposure of nests and desiccation of eggs and mortality associated with movement of juveniles into less-optimal habitat where food may be less available and vulnerability to predation may increase.

For this programmatic impact assessment, CALFED actions that minimize flow reduction in rivers over short time intervals are assumed to improve habitat conditions affected by water surface-level fluctuation and have beneficial impacts on affected species. Additionally, actions to reduce stranding by restructuring habitat are also considered to have beneficial impacts. Actions to reduce stranding may include filling gravel mining pits; establishing permanent connections between oxbows and sloughs and the main river channel; and contouring the flood bypasses to efficiently drain isolated ponds, rice fields, and sloughs to the main channels.

For reservoirs, monthly drawdown is calculated by comparing the surface elevation at the end of an applicable period (e.g., day, month) with the elevation in the preceding period for each reservoir. Reduced rates of drawdown are assumed to reduce mortality attributable to short-term water surface-level fluctuation and have beneficial impacts on reservoir species.

MOVEMENT RELATIONSHIPS

Movement of organisms includes passive transport, migration, and attraction. Maintaining active or passive movement patterns is a concern for all representative species. Effects of project actions on a species is dependent on life stage characteristics. For example, the movement patterns of American shad and striped bass will be affected primarily during the planktonic egg and larval life stages. Chinook salmon, steelhead, and sturgeon are affected during up- and downstream migration of adults and juveniles.

Environmental conditions that support passive and active movement of eggs, larvae, juveniles, and adults to habitat that facilitate growth, reproduction, and survival are assumed to have beneficial impacts for the selected species. The environmental variables considered in assessing movement conditions are flow, diversion, barriers, physical habitat, water quality, and species interactions. Project actions that enhance environmental conditions supporting transport, migration, and attraction include:

- Re-establish flow variability that approximates the natural seasonal flow variability or meets species needs within the constraints of the existing ecological landscape;

- Re-establish flow conditions in Delta channels, including net and tidal flow effects, that emulate natural channel flow conditions or meet species needs within the constraints of the existing ecological landscape; and

- Remove and modify barriers, install and improve fish passage facilities, or restore and modify channel structure to facilitate access to resources and conditions that allow an speices to survive and reproduce.

In rivers, migration cues for juvenile chinook salmon, steelhead, and other species are not thoroughly understood and data supporting species-specific flow requirements during migration have not been developed for all streams and all speices. CALFED actions may include discharge of flow to facilitate successful juvenile salmonid outmigration and restore other natural ecosystem processes. When data is available, relationships between species movement and flow under existing ecosystem conditions will be used in the assessment. However, information on the need and timing for flow events is generally unavailable and flow that emulates natural conditions is assumed to improve survival during downstream movement of juvenile chinook salmon and steelhead; striped bass eggs and larvae; sturgeon larvae and juveniles; and American shad eggs, larvae, and juveniles. Although the mechanism for increased survival is unclear, high spring river flow is associated with increased abundance of San Joaquin River fall-run chinook salmon, higher survival of striped bass eggs and larvae, and increased fall abundance of young-of-year American shad (California Department of Fish and Game 1992b, 1987b, 1987c; Stevens and Miller 1983).

For this impact assessment, CALFED actions that provide flow events consistent with natural flow patterns and consistent with species needs are assumed to move juvenile fish into suitable rearing areas, provide cues that reduce outmigration delay, and increase survival. See "Flow" discussed above under "Ecosystem-Level Analysis" for the assessment method.

In the Delta, natural net channel conditions (i.e., flow toward Suisun Bay) are assumed to facilitate movement of organisms to downstream habitat more conducive to increased growth and survival. Changes in Delta channel flow conditions are assessed for chinook salmon, steelhead, striped bass, delta smelt, and longfin smelt. Flow-survival and flow-abundance relationships are not strongly supported by available data; however, some data indicate that increased QWEST may increase survival of juvenile chinook salmon (U.S. Fish and Wildlife Service 1993). Increased net Delta outflow increases the proportion of young-of-year striped bass and delta smelt in Suisun Bay (California Department of Fish and Game 1992a, 1992b; California Department of Water Resources and U.S. Bureau of Reclamation 1993). Increased net Delta outflow has been associated with increased total abundance of young-of-year striped bass and longfin smelt (California Department of Fish and Game 1992b, Jassby 1993).

For chinook salmon of both Sacramento River and San Joaquin River origin, mortality during migration through the Delta may vary depending on pathway and existing environmental conditions. Outmigrating juvenile chinook salmon are assumed to enter DCC and Georgiana Slough in proportion to the net flow division from the Sacramento River (U.S. Fish and Wildlife Service 1987). Under existing conditions, the mortality of juvenile chinook salmon that move into DCC and Georgiana Slough from the Sacramento River is greater than the mortality of juvenile chinook salmon that continue down the Sacramento River toward Rio Vista. Increased mortality may be attributable to predation, adverse water temperature, toxicants, and diversion in the central and south Delta. A reduced proportion of Sacramento River flow entering DCC and Georgiana Slough is assumed to reduce the mortality of juvenile chinook salmon. Steelhead are assumed to be affected similarly.

A change in Delta structure that increases the proportion of Sacramento River flow entering the Mokelumne River channels through a new flow division at Hood or near DCC, however, could improve conditions in the Mokelumne River channels and reduce mortality of juvenile chinook salmon moving with the flow division. Reduced flow in the Sacramento River could increase mortality of juvenile chinook salmon that remain in the main river channel. Existing information is insufficient to determine the effects of substantial increased flow to the Mokelumne River channels on survival of juvenile chinook salmon.

For San Joaquin River chinook salmon, juveniles that move with flow into Old River at Mossdale may suffer greater mortality than juvenile chinook salmon that continue down the San Joaquin River toward Stockton (U.S. Fish and Wildlife Service 1987, 1990); however, the relationship is not as clearly supported as the relationship discussed above for chinook salmon entering DCC from the Sacramento River (U.S.

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Fish and Wildlife Service 1987, 1990). Additionally, closure of Old River may increase entrainment of delta smelt, striped bass, and other species in the central and south Delta. Construction of an operable barrier on Old River at Mossdale could provide the opportunity to reduce potential mortality associated with the flow division into Old River at Mossdale. Future studies are required to determine the operation of an Old River barrier that provides benefits to San Joaquin fall-run chinook salmon while avoiding adverse impacts on other fish species in the central and south Delta.

Juvenile and adult chinook salmon and steelhead move through, over, or around barriers during downstream and upstream migration. Mortality, reduced fecundity, or reduced spawning success may result from delay, abrasion, and predation associated with barriers or the flow conditions created by barriers (e.g., mortality of juvenile chinook salmon at Red Bluff Diversion Dam [Vogel 1995]). Barriers may provide habitat and increased feeding opportunity for predatory fish (e.g., by disorienting and delaying migration of juvenile fish). For the impact assessment, improvements that reduce the adverse effects of barriers, including predation, are assumed to increase survival during migration of juvenile and adult chinook salmon and steelhead.

Flow-related cues affect movement of organisms to habitat essential for growth, reproduction, and survival. Flow-related cues may result in adult salmon straying into habitat where reproductive success is reduced (e.g., chinook salmon straying into the San Joaquin River and drainage canals upstream of the mouth of the Merced River, chinook salmon straying into the Colusa Basin drain). Adult chinook salmon and steelhead benefit from installation of fish barriers or flow changes that reduce straying into areas that do not support successful reproduction.

The actions discussed above are assumed to enhance environmental conditions supporting transport, migration, and attraction and to benefit species of interest. Incomplete knowledge of species needs and unpredictable responses to actions, however, may adversely impact some species. Implementation of actions that support movement will depend on developing knowledge of species needs and understanding effects of the actions. Beneficial impacts of actions to improve transport, migration and attracitions can be assured only through implementation programs that include adaptive management.

SPECIES INTERACTIONS

Predation is natural in the system; however, fish and other aquatic organisms that are stressed by toxicants, elevated water temperatures, turbulence created by barriers or screening facilities, and other factors may be more susceptible to predation and experience artificially high mortality rates. Past inchannel gravel mining in specific areas has also altered channel morphological characteristics and created predator habitat. CALFED actions that reduce predator populations, reduce habitat for predators, and reduce stress attributable to toxicants, water temperature, turbulence, or other factors, are assumed to increase survival of juvenile fish and other organisms susceptible to high predation rates.

Introduction of non-native species has had major effects on the species composition of the Bay-Delta system. CALFED actions that reduce or eliminate the influx of non-native aquatic species from ship ballast water and the potential for influx of non-native aquatic plant and animal species at border crossings or through inter-watershed connections are assumed to minimize unnatural levels of competition, predation, and disease potentially associated with establishment of non-native species populations.

ARTIFICIAL PRODUCTION

Artificial production of chinook salmon, steelhead, striped bass, and other species can increase predation and competition with naturally produced populations, lower the genetic integrity of natural populations, and increase harvest rates on natural populations. CALFED actions that address stocking practices are assumed to have beneficial impacts. Actions may include marking hatchery-produced fish, considering stocking location and timing relative to natural fish population sensitivity, and developing hatchery practices consistent with management needs of natural fish populations.

HARVEST

Illegal and legal harvest of anadromous fish, such as chinook salmon, steelhead, and striped bass, has been identified as a factor affecting natural production. CALFED actions that address illegal and legal harvest are assumed to have beneficial impacts. Actions may include additional law enforcement, cooperative programs to increase public awareness, providing a means for reporting illegal harvest violations, and recommendations to the regulatory agencies for improved harvest practices relative to maintaining natural fish populations.

SIGNIFICANCE CRITERIA

According to the CEQA Guidelines, an adverse effect is considered significant if it:

- Substantially degrades aquatic ecosystem processes,
- Substantially changes structural characteristics of the aquatic ecosystem in an adverse direction,
- Substantially degrades conditions affecting or potentially affecting the abundance or range of a rare, threatened, and endangered species or a species having economic or social value, or
- Has considerable cumulative effects when viewed with past, current, and reasonably foreseeable future projects.

Given the CALFED objectives to improve and increase aquatic habitats and to improve ecological functions in the Bay-Delta, any effect that clearly contributes to cumulative adverse impacts was considered potentially significant.

For this analysis, impacts were considered potentially significant when implementing a project action would:

- Cause or contribute to substantial short- or long-term adverse changes in aquatic ecosystem structure and processes, or
- Degrade conditions that potentially reduce abundance and distribution of species populations.

ENVIRONMENTAL CONSEQUENCES

The presentation of impacts is organized by alternative and subdivided into ecosystem-level and species-specific impacts. The ecosystem-level analysis focuses on change in functional and structural characteristics of each region. Functional characteristics include flow; water temperature; sediment, nutrient, and contaminant input and movement; and productivity. Structural characteristics include distinct surface and subsurface features of the ecosystem. Discussion of species-specific impacts focuses on changes in conditions that may affect species abundance and distribution.

Conditions considered in the evaluation for each species include habitat, water quality, entrainment, water surface level variability, movement, species interactions, artificial production, and harvest. When appropriate, the species-specific analysis is tied to the ecosystem-level analysis.

To avoid redundant discussions, impacts are described for the first alternative or region where they occur. If the same impacts occur under other alternatives or in other regions, the occurrence is noted when the impact is first described. For example, actions included in CALFED programs that would be implemented under all alternatives are discussed under Alternative 1. When actions vary in one program and affect the impact of actions in programs that do not vary between alternatives, such as actions in the Conveyance Program that affect the impact of actions in the Water Quality Program, the direct and interactive effects are discussed under the appropriate alternative.

Comparison of No Action Alternative to Existing Conditions

ALL REGIONS

Effects of the No Action Alternative were evaluated relative to existing conditions. The differences between the No Action Alternative and existing conditions result primarily from changes in water project operations in response to new or modified facilities and increased or reduced demands (Table 6). New or modified facilities include new surface-water and groundwater storage, new conveyance structures, and modified reservoir discharge structures. Change in demands for water result from increased SWP and CVP needs, land retirement, full use of existing water rights, revised environmental flow needs, and increased wildlife refuge needs.

Increased Delta export under the No Action Alternative would increase entrainment of nutrients and organisms, including increased losses of delta smelt, chinook salmon, striped bass, longfin smelt, and other Delta species. In all regions, increased input of urban and industrial contaminants would increase stress on biological processes, such as organism growth and fecundity and organism susceptibility to disease, and would adversely affect aquatic species' population distribution and abundance. In the American River, simulated flow under the No Action Alternative is lower from May through September, and rearing conditions for steelhead and chinook salmon may be adversely affected by increased water temperature associated with reduced flow.

DELTA REGION

Delta structure and facility operations rules would be similar for existing conditions and the No Action Alternative. Except for the effects of change in inflow and exports, the existing flow patterns in the Delta would be relatively unchanged. Demands upstream and south of the Delta would increase under the No Action Alternative.

Although effects on simulated inflow and outflow patterns are small relative to existing conditions, exports would increase an average of 309 thousand acre-feet (TAF) per year (5%) under the No Action Alternative, primarily affecting conditions from January through March and in July, August, and October (Table 7). Existing adverse effects of SWP and CVP exports would continue, and additional exports would increase the loss of Delta productivity and nutrients. Entrainment of fish species also would increase, including increased loss of longfin smelt; winter-, fall-, and spring-run chinook salmon juveniles; delta smelt; striped bass; and other Delta species. Higher exports also would increase net reverse flow in Old and Middle rivers, transporting additional

Sacramento River flow toward the export facilities. Transport of Sacramento River flow to the central and south Delta may disrupt migration cues and adversely affect survival of juvenile delta smelt, striped bass, and chinook salmon.

Water temperature conditions in the Delta under the No Action Alternative essentially would be similar to those under existing conditions. Water temperature below the major dams on the Sacramento and eastside tributary rivers can be modified by releases of cool water from deep within the reservoirs, but the released water quickly approaches ambient air temperature as it moves downstream. Inflow water temperature is almost completely dependent on ambient air temperature by the time it reaches the Delta.

Even very large reservoirs with the structural ability to release deep, cold water (such as Lake Shasta) have minimal effect on water temperature in the Delta. Most water in the Delta moves in large channels where wind, turbulence, and tidal mixing prevent stratification. Trees and shrubs along Delta sloughs provide microhabitat cooling that benefits some species. The amount of SRA habitat in the Delta is limited, and no significant differences are expected in the extent of SRA between existing conditions and the No Action Alternative.

Sediment movement to the Delta is determined by the magnitude of winter and spring runoff events. Dams have reduced the magnitude of flood events and reduced input of sediments to downstream reaches. Reservoirs behind large dams capture and retain sediments that would otherwise move down the river in a natural sediment recruitment process. Levees along rivers and in the Delta constrict channel widths and contribute to increased velocity that moves sediment quickly downstream. Riprap of channel banks has a similar effect. The No Action Alternative includes a number of reservoir projects that may affect sediment

Criterion, Assumption, or Project	Change from Existing Conditions				
	Flow	Diversion	Storage	Water Quality	Habitat
2020 level of development	✓	✓	✓		
Increased CVP demands	✓	✓	✓		
Increased SWP demands	✓	✓	✓		
Tuolumne and Yuba rivers flow	✓	✓	✓		
Western San Joaquin Valley: 45,000 acres retired	✓	✓	✓	✓	✓
Coastal aqueduct (Branch II)	✓	✓	✓		✓
CVPIA (partial: 800 TAF, Level IV refuge water, Shasta temperature control device)	✓	✓	✓		✓
Kern Water Bank	✓	✓	✓		✓
Los Vaqueros Reservoir Project	✓	✓	✓		✓
Metropolitan Water District Eastside Reservoir Project	✓	✓	✓		✓
New Melones conveyance	✓	✓	✓		✓
Sacramento River flood control system evaluation					✓
Semitropic groundwater banking	✓	✓	✓		✓
Stone Lakes National Wildlife Refuge					✓

NOTES:

CVP = Central Valley Project
CVPIA = Central Valley Project Improvement Act.
SWP = State Water Project.
TAF = Thousand acre-feet.

Table 6. Comparison of No Action Alternative to Existing Conditions

supply and transport, but their impact would be minimal because the main sources of sediment to the Delta currently are blocked by existing dams. Sediment and nutrient input and movement may be affected by actions upstream of the Delta, including land retirement and the Sacramento River Flood Control Project. None of the projects would substantially change the structure of the existing ecosystem; change in sediment and nutrient input and movement, and subsequent effects on biological processes, most likely would be minimal.

The main sources of contaminants affecting the Delta are mine drainage, agricultural returns, industrial centers, treated municipal wastewater, and urban runoff. Heavy metals of concern include cadmium, copper, mercury, selenium, and zinc. Mines, treated wastewater discharge, urban runoff, and groundwater contribute heavy metals that are toxic and may be bioaccumulated by Delta species. Organophosphate insecticides, such as diazinon, chlorpyrifos, and carbofurans, are used extensively throughout the Central Valley and enter the rivers with groundwater, agricultural return flow, and runoff associated with winter rains. Insecticides have been measured in Delta waters at levels toxic to aquatic organisms, most commonly during early spring. Contaminant input and movement from agricultural sources could be reduced by land retirement upstream of the Delta and, possibly, by restoration associated with the Stone Lakes National Wildlife Refuge.

Relative to existing sources of contaminants, contaminant input under the No Action Alternative would increase, primarily attributable to urban and industrial growth (CALFED 1997b). The relatively minor change in flow discussed above would have minimal effects on the movement and dilution of contaminants. Increased input of urban and industrial contaminants would increase stress on biological processes, such as reduced organism growth and fecundity and increased organism susceptibility to disease, and would adversely affect species' population distribution and abundance. Urban and industrial growth also would increase contaminant input to the aquatic ecosystem in the Bay, Sacramento River, and San Joaquin River regions.

Productivity is affected by the processes discussed above and changes in structural characteristics described below. Relative to existing conditions, projects under the No Action Alternative that could increase biological productivity in the aquatic ecosystem include changes in wildlife refuge operations and restoration associated with the Stone Lakes National Wildlife Refuge and the Sacramento River Flood Control Project. Restoration of riparian, SRA, and tidal marsh areas could slightly increase productivity through increased input of organic carbon and provide a small benefit to Delta species. As discussed above, increased exports may increase the loss of productivity and may negate any slight gain attributable to restoration of Delta habitats.

Structural characteristics of the Delta would be similar for both existing conditions and the No Action Alternative. Restoration associated with the Stone Lakes National Wildlife Refuge may increase structural complexity of Delta channels in the refuge and increase species' habitat availability. Change in structural characteristics was considered beneficial when the change moved toward a natural condition. Restoring tidal marshes and connecting sloughs in the Stone Lakes National Wildlife Refuge would allow development of natural riparian and marsh communities and would result in minor beneficial effects relative to the existing Delta aquatic system. The structural changes could result in a slight increase in spawning and rearing habitat for Delta species, including chinook salmon, Sacramento blackfish, splittail, largemouth bass, and striped bass.

BAY REGION

Under the No Action Alternative, effects on fisheries and aquatic resources in the Bay Region primarily would result from change in Delta outflow and subsequent movement of contaminants, sediment, nutrients, and production from the Delta Region. Under the No Action Alternative, Delta exports would increase relative to existing conditions; however, change in simulated Delta outflow would be small and have little effect on the Bay Region ecosystem (Table 7).

SACRAMENTO RIVER REGION

Under the No Action Alternative, changes in the allocation of the dedicated water under the Central Valley Project Improvement Act (CVPIA) may affect flows in the mainstem Sacramento and American rivers (Table 6). With the 2020 level of development, SWP and CVP Delta exports would increase, potentially altering flow release patterns in the Sacramento, American, and Feather rivers. Flow releases on the Yuba River may be altered to meet conditions of a revised Federal Energy Regulatory Commission (FERC) agreement. Simulated Sacramento River flow for the No Action Alternative is similar to flow simulated for existing conditions (Table 7). Flows during September would be higher than flows under existing conditions; however, flows under existing conditions exceed flows that would occur naturally. Although the higher flows may benefit some species, such as winter-run chinook salmon and steelhead, higher flows under the No Action Alternative may adversely affect invertebrate populations and riparian vegetation.

The simulated flow in the Feather River under the No Action Alternative is similar to flow under existing conditions. During April, the frequency of flow below natural levels is increased (Table 7). The lower flows could adversely affect rearing and migration of juvenile fall-run chinook salmon, although effects most likely would be similar to existing conditions. In the American River, simulated flow under the No Action Alternative is lower from May through September. The reduced flow more closely approximates the natural condition (except during May); however, steelhead and chinook salmon currently are restricted to habitat below Nimbus Dam, and migration and rearing conditions may be adversely affected by increased water temperature associated with reduced flow.

Water temperature changes attributable to flow changes were discussed previously. The Shasta temperature control structure would provide the opportunity to improve water temperature conditions in the Sacramento River. The Shasta temperature control structure would improve management of the coldwater pool, allowing release of warmer water during periods of low species sensitivity or low ambient air temperature. The coldwater pool in the reservoir is conserved for use during periods of greater species sensitivity and months when river water temperatures may exceed species needs. The additional flexibility for water temperature control would benefit all runs of chinook salmon and steelhead spawning and rearing in the Sacramento River.

Abandoned mines in the Sacramento River basin discharge acidified water loaded with dissolved metals that may cause short- and long-term toxic effects. Storm-related spill events deposit large amounts of cadmium, copper, zinc, and mercury into the rivers. High concentrations of metals have been associated with fish kills in the Sacramento River. Contaminants from mines, agriculture, and municipal waste treatment are not specifically addressed under existing conditions or the No Action Alternative; however, ongoing programs are expected to alleviate future mine discharge problems under each.

The Sacramento River Flood Control Project may affect structural characteristics of the Sacramento and American rivers. Changes in structural characteristics that result in a more

Month	Existing Conditions		No Action Alternative	
	Frequency Below Low Range (%)	Frequency Above High Range (%)	Frequency Below Low Range (%)	Frequency Above High Range (%)
Exports[a]				
October	16	25	19	34
November	21	0	19	5
December	15	8	15	11
January	7	18	8	51
February	14	16	10	42
March	12	7	14	45
April	23	22	40	0
May	19	22	26	3
June	10	18	12	18
July	16	0	15	44
August	15	22	15	59
September	23	22	18	27
Delta Outflow[b]				
October	56	8	52	4
November	53	5	58	5
December	40	5	37	5
January	19	10	19	8
February	29	12	29	10
March	44	7	51	5
April	75	3	75	4
May	85	0	85	0
June	84	1	85	1
July	38	0	38	0
August	97	0	97	0
September	0	100	0	71
Sacramento River Flow at Keswick[b]				
October	0	33	0	27
November	8	7	18	4
December	22	1	23	1
January	26	3	25	3
February	59	3	62	3
March	68	5	71	5
April	68	3	71	3
May	16	1	16	1
June	0	79	0	71
July	0	100	0	100
August	0	100	0	100
September	0	100	0	71
Feather River Flow[b]				
October	0	47	0	44
November	0	8	3	7
December	7	12	8	12
January	0	23	0	23
February	4	32	5	29

Table 7. Variability in Exports and Flows under Existing Conditions and the No Action Alternative (Page 1 of 2)

Month	Existing Conditions		No Action Alternative	
	Frequency Below Low Range (%)	Frequency Above High Range (%)	Frequency Below Low Range (%)	Frequency Above High Range (%)
Feather River Flow (Continued)				
March	15	32	16	29
April	36	12	44	12
May	37	14	33	14
June	0	23	0	26
July	1	86	0	84
August	0	81	0	85
September	0	99	0	100
American River Flow[b]				
October	0	86	0	84
November	0	10	0	7
December	0	10	0	10
January	0	15	0	12
February	7	10	4	10
March	30	8	32	8
April	63	1	68	1
May	70	0	78	0
June	1	7	1	7
July	0	88	0	81
August	0	100	1	82
September	0	100	0	71
San Joaquin River Flow at Vernalis[b]				
October	0	79	0	81
November	0	3	0	3
December	0	4	0	4
January	0	8	0	7
February	1	7	1	7
March	44	5	47	5
April	86	1	84	1
May	90	0	88	0
June	81	1	77	1
July	0	1	4	1
August	0	0	0	1
September	0	42	0	58

NOTES:

[a] Low range is the average export for existing conditions minus 1 standard deviation or the minimum export, whichever is largest. High range is the average export for existing conditions plus 1 standard deviation or the maximum export, whichever is smallest.

[b] Low range is the average flow for unimpaired conditions minus 1 standard deviation or the minimum flow, whichever is largest. High range is the average flow for unimpaired conditions plus 1 standard deviation or the maximum flow, whichever is smallest.

SOURCES:
DWRSIM, CALFED 1997a.

Table 7. Variability in Exports and Flows under Existing Conditions and the No Action Alternative (Page 2 of 2)

natural condition were considered beneficial to aquatic resources. Changes in levee maintenance practices that allow development of riparian and SRA communities would have slight beneficial impacts relative to the existing levee maintenance practices. Riparian community development may slightly increase rearing habitat for several fish species, including chinook salmon, steelhead, and splittail, because of increases in available cover, nutrient input, primary productivity, and bank stability; however, benefits most likely would be small because of ongoing needs to maintain flood control capacity and ongoing effects of the existing flood control structure.

SAN JOAQUIN RIVER REGION

Based on the simulated flows, flow and water temperature conditions under the No Action Alternative would be similar to those under existing conditions. More detailed information is required to determine the short-term effects of implementation of future agreements related to flow and related environmental conditions on the Tuolumne River and in the mainstem San Joaquin River.

Agricultural contaminants, including fertilizers and pesticides, enter the San Joaquin River in numerous agricultural return drains and from rainwater runoff during winter. Simazine is found at Vernalis in almost all months; diazinon and cyanazine are found in the water samples at Vernalis in winter and early spring. Each of these chemicals is present as a result of pesticide applications. Nitrogen and phosphorous from fertilizer application enter the San Joaquin River in return-flows, increasing primary productivity and eutrophication (a process during which waterbodies become nutrient rich, in turn producing high amounts of vegetation and aquatic organisms that may deplete the dissolved oxygen supply).

The retirement of 45,000 acres of agricultural land most likely would occur in the western San Joaquin River Region. Land retirement could reduce the input of contaminants and nutrients to the San Joaquin River and result in a beneficial impact relative to eutrophication and toxic conditions. Because the change in agricultural acreage would be small relative to total agricultural acreage in the San Joaquin Region, water quality conditions most likely would be similar under both existing conditions and the No Action Alternative.

Land retirement to reduce input of contaminants to the San Joaquin River would have a beneficial impact on survival and spawning success of aquatic species, including chinook salmon and Sacramento splittail.

SWP AND CVP SERVICE AREAS OUTSIDE THE CENTRAL VALLEY

The 2020 level of development under the No Action Alternative, including increased exports from SWP and CVP Delta facilities, may induce growth in the SWP and CVP Service Areas Outside the Central Valley. Additional agricultural or urban development may affect aquatic ecosystems in the service areas. Implementation of the CVPIA also may affect water deliveries to service areas outside the Central Valley. Specific impacts cannot be determined with available information.

The Metropolitan Water District (MWD) Eastside Reservoir Project would create additional habitat for reservoir species. The Coastal Aqueduct and the MWD Inland Feeder Project would transport Delta water to streams, reservoirs, and estuaries outside the Central Valley. Introduction of non-native species to, and establishment in, areas currently isolated from the Central Valley may result in adverse impacts on native species, including increased competition for resources, predation, and disease.

Comparison of CALFED Alternatives to No Action Alternative

Table 8 presents a summary of beneficial and adverse impacts of CALFED alternatives on fisheries and aquatic resources. Table 9 presents similar information for listed species and species proposed for listing.

IMPACT ISSUES	ALTERNATIVE 1			ALTERNATIVE 2				ALTERNATIVE 3				
	1A	1B	1C	2A	2B	2D	2E	3A	3B	3E	3H	3I
Delta Region												
Change in CVP and SWP exports from the south Delta would impact: *– entrainment loss of organisms and nutrients;* *– entrainment of fish species; and* *– net reverse flow in the south and central Delta; potentially affecting productivity and migration of fish species.*	○	○	◗	◗	◗	◗	◗	+	+	+	+	+[1]
The screened through-Delta facilities and the isolated facility intake would cause entrainment-related mortality for Sacramento River fish.	□	□	□	◗	◗	◗	□	◗	◗	◗	◗	◗
Through-Delta facilities would increase cross-Delta flow, potentially: *– reducing productivity in the Mokelumne River channels; and* *– increasing movement of fish from the Sacramento River and into the Mokelumne River channels.*	□	□	□	◗	◗	◗	◗	□	□	□	◗	□
Through-Delta facilities and the isolated facility would reduce habitat quality and fish survival through: *– increased proportion of flow and fish drawn off the Sacramento River and into Georgiana Slough;* *– reduced Sacramento River flow; and* *– an upstream shift in X2.*	□	□	□	◗	◗	◗	◗	◗	◗	◗	◗	◗

Table 8. Summary of Environmental Impacts Related to Fish and Aquatic Ecosystem (Page 1 of 5)

IMPACT ISSUES	ALTERNATIVE 1			ALTERNATIVE 2				ALTERNATIVE 3				
	1A	1B	1C	2A	2B	2D	2E	3A	3B	3E	3H	3I
Adult fish bound for the Sacramento River would be attracted by cross-Delta flow into the Mokelumne River channels and their return to the Sacramento River would be blocked by fish screens.	□	□	□	◗	◗	◗	□	□	□	□	□	□
The through-Delta and isolated facilities would increase net flow in the lower San Joaquin River, potentially improving conditions affecting migration of fish toward the Bay.	□	□	□	+	+	+	+	+	+	+	+	+
Construction of an intertie between the existing CVP intake and Clifton Court Forebay may increase entrainment of organisms and nutrients from the south Delta.[2]	□	◗	◗	◗	◗	◗	◗	□	□	□	□	□
South-Delta barriers potentially reduce connectivity to other Delta channels, reduce water quality conditions, and increase loss of nutrients and organisms from south-Delta channels (increased Old and Middle Rivers flow toward the CVP and SWP export facilities under Configurations 1B, 1C, and Alternative 2).	□	◗	◗	◗	◗	◗	◗	o[1]	o[1]	o[1]	o[1]	o[1]
The head-of-Old-River barrier may improve survival of juvenile chinook salmon from the San Joaquin River.	□	+	+	+	+	+	+	+	+	+	+	+
Ecosystem Restoration Program actions provide short-term flow events that reestablish ecosystem processes and structure, improving habitat conditions for fish and aquatic species.	+	+	+	+	+	+	+	+	+	+	+	+

Table 8. Summary of Environmental Impacts Related to Fish and Aquatic Ecosystem (Page 2 of 5)

IMPACT ISSUES	ALTERNATIVE 1			ALTERNATIVE 2				ALTERNATIVE 3				
	1A	1B	1C	2A	2B	2D	2E	3A	3B	3E	3H	3I
Conversion of managed wetlands and agricultural land to inundated wetlands and open water would reestablish the natural structure of the Delta and increase abundance of species habitat.	+	+	+	+	+	+	+	+	+	+	+	+
Creation of riparian communities and floodplain/meander belts will reestablish natural channel processes and structure and increase and improve species habitat. (all regions)	+	+	+	+	+	+	+	+	+	+	+	+
CALFED actions (Water Quality and Ecosystem Restoration Programs) would reduce contaminant input relative to the No Action Alternative, potentially increasing productivity and species survival. (all regions)	+	+	+	+	+	+	+	+	+	+	+	+
New fish screens on agricultural, municipal, industrial, and managed wetland diversions would reduce fish entrainment loss. (all regions)	+	+	+	+	+	+	+	+	+	+	+	+
Management actions in the Ecosystem Restoration Program would be implemented to integrate artificial production goals consistent with rehabilitation of naturally producing fish populations. (all regions)	+	+	+	+	+	+	+	+	+	+	+	+
Ecosystem Restoration Program actions, including restrictions on discharge of ship ballast water and transport of non-native species at border crossings, direct control of non-native species populations, and reduced predator habitat, may reduce and prevent unnatural levels of predation and competition. (all regions)	+	+	+	+	+	+	+	+	+	+	+	+

Table 8. Summary of Environmental Impacts Related to Fish and Aquatic Ecosystem (Page 3 of 5)

IMPACT ISSUES	ALTERNATIVE 1			ALTERNATIVE 2				ALTERNATIVE 3				
	1A	1B	1C	2A	2B	2D	2E	3A	3B	3E	3H	3I
Ecosystem Restoration Program actions would include management recommendations to reduce harvest-related impacts on self-sustaining natural fish populations. (all regions)	+	+	+	+	+	+	+	+	+	+	+	+
Bay Region												
Conversion of managed wetlands and agricultural land to inundated wetlands and open water would reestablish the natural structure of the Bay including Suisun Marsh and increase abundance of species habitat.	+	+	+	+	+	+	+	+	+	+	+	+
Sacramento River and San Joaquin River Regions												
Ecosystem Restoration Program actions provide short-term flow events that reestablish ecosystem processes and structure, improving habitat conditions for fish and aquatic species.	+	+	+	+	+	+	+	+	+	+	+	+
Construction and operation of new reservoirs, depending on location, could eliminate existing spawning and rearing habitat and increase entrainment loss of juvenile fish. (Primarily for the Sacramento Region)	□	□	●	□	●	□	●	□	●	●	●	●

Table 8. Summary of Environmental Impacts Related to Fish and Aquatic Ecosystem (Page 4 of 5)

IMPACT ISSUES	ALTERNATIVE 1			ALTERNATIVE 2				ALTERNATIVE 3				
	1A	1B	1C	2A	2B	2D	2E	3A	3B	3E	3H	3I
SWP and CVP Service Areas												
Additional water supply may increase urban and industrial development and cause additional degradation of the aquatic environment through increased contaminant input, increased incidence of human-caused disturbance, and other factors.	○	○	◗	◗	◗	◗	◗	◗	◗	◗	◗	◗

NOTE: Please refer to supporting text for a discussion of the degree to which the beneficial or adverse impacts vary from one configuration to the other.

LEGEND:
Level of Impact

- ● = Significant and unavoidable
- ◗ = Significant and mitigable
- ○ = Less than significant
- □ = None
- + = Beneficial
- U = Unknown

[1]Depending on operations, the alternative could cause significant adverse impacts.
Note: All CALFED alternatives are compared to the No Action Alternative.

Table 8. Summary of Environmental Impacts Related to Fish and Aquatic Ecosystem (Page 5 of 5)

IMPACT ISSUES	LISTED OR PROPOSED SPECIES[1]	ALTERNATIVE 1[2]			ALTERNATIVE 2[2]				ALTERNATIVE 3[2]				
		1A	1B	1C	2A	2B	2D	2E	3A	3B	3E	3H	3I
Delta Region													
Change in CVP and SWP exports from the south Delta would impact: - food availability - entrainment loss, - movement and migration	delta smelt	○	○	◗	◗	◗	◗	◗	+	+	+	+	+[3]
	winter-run	○	○	○	○	○	○	○	+	+	+	+	+[3]
	spring-run	○	○	○	○	○	○	○	+	+	+	+	+[3]
	steelhead	○	○	○	○	○	○	○	+	+	+	+	+[3]
	splittail	◗	○	◗	◗	◗	◗	◗	+	+	+	+	+[3]
Construction of a through-Delta facility in Configurations 2A, 2B, and 2D and the south-Delta barriers in Configurations 1B, 1C, 2A, 2B, 3A, and 3B would modify and destroy spawning and rearing habitat.	delta smelt	□	◗	◗	◗	◗	◗	□	◗	◗	□	□	□
	splittail	□	◗	◗	◗	◗	◗	□	◗	◗	□	□	□
X2 may shift farther upstream in the Delta during summer and fall in response to reduced net Sacramento River flow past Rio Vista, potentially reducing habitat quantity and quality for organisms associated with X2.	delta smelt	□	□	□	◗	◗	◗	◗	◗	◗	◗	◗	◗
The through-Delta and isolated facilities would increase the proportion of juvenile fish drawn into Georgiana Slough and the Mokelumne River channels.	winter-run	□	□	□	◗	◗	◗	◗	◗	◗	◗	◗	◗
	spring-run	□	□	□	◗	◗	◗	◗	◗	◗	◗	◗	◗
	steelhead	□	□	□	◗	◗	◗	◗	◗	◗	◗	◗	◗
	splittail	□	□	□	U	U	U	U	U	U	U	U	U
The through-Delta and isolated facilities would increase in the lower San Joaquin River, flow toward improving conditions affecting movement of fish toward Suisan Bay.	delta smelt	□	□	□	+	+	+	+	+	+	+	+	+
	winter-run	□	□	□	+	+	+	+	+	+	+	+	+
	spring-run	□	□	□	+	+	+	+	+	+	+	+	+
	steelhead	□	□	□	+	+	+	+	+	+	+	+	+
	splittail	□	□	□	U	U	U	U	U	U	U	U	U

Table 9. Summary of Environmental Impacts Related to Listed and Proposed Species (Page 1 of 5)

IMPACT ISSUES	LISTED OR PROPOSED SPECIES[1]	ALTERNATIVE 1[2]			ALTERNATIVE 2[2]				ALTERNATIVE 3[2]				
		1A	1B	1C	2A	2B	2D	2E	3A	3B	3E	3H	3I
Ecosystem Restoration Program actions, including restrictions on discharge of ship ballast water and transport of non-native species at border crossings, direct control of non-native species populations, and reduced predator habitat, may reduce and prevent unnatural levels of predation and competition. (all regions)	All species	+	+	+	+	+	+	+	+	+	+	+	+
Ecosystem Restoration Program actions would include management recommendations to reduce harvest-related impacts on self-sustaining natural fish populations. (all regions)	winter-run	+	+	+	+	+	+	+	+	+	+	+	+
	spring-run	+	+	+	+	+	+	+	+	+	+	+	+
	steelhead	+	+	+	+	+	+	+	+	+	+	+	+
Management actions in the Ecosystem Restoration Program would be implemented to integrate artificial production goals consistent with rehabilitation of naturally producing fish populations. (all regions)	All species	+	+	+	+	+	+	+	+	+	+	+	+
New fish screens on agricultural, municipal, industrial, and managed wetland diversions would reduce fish entrainment loss. (all egions)	All species	+	+	+	+	+	+	+	+	+	+	+	+
Bay Region													
Conversion of managed wetlands and agricultural land to inundated wetlands and open water	All species	+	+	+	+	+	+	+	+	+	+	+	+

Table 9. Summary of Environmental Impacts Related to Listed and Proposed Species (Page 3 of 5)

IMPACT ISSUES	LISTED OR PROPOSED SPECIES[1]	ALTERNATIVE 1[2]			ALTERNATIVE 2[2]				ALTERNATIVE 3[2]				
		1A	1B	1C	2A	2B	2D	2E	3A	3B	3E	3H	3I
Sacramento River Region													
Reoperation of Reservoirs potentially degrades water temperature conditions and increases spawning and rearing mortality	winter-run	◗	◗	◗	◗	◗	◗	◗	◗	◗	◗	◗	◗
	spring-run	○	○	○	○	○	○	○	○	○	○	○	○
	steelhead	◗	◗	◗	◗	◗	◗	◗	◗	◗	◗	◗	◗
Construction and operation of new reservoirs, depending on location, could eliminate existing spawning and rearing habitat and increase entrainment loss of juvenile fish.	winter-run			◗		◗		◗		◗	◗	◗	◗
	spring-run			◗		◗		◗		◗	◗	◗	◗
	steelhead			●		●		●		●	●	●	●
Ecosystem Restoration Program actions would reestablish natural short-term flow events and improve environmental conditions affecting spawning, rearing, and migration.	winter-run	+	+	+	+	+	+	+	+	+	+	+	+
	spring-run	+	+	+	+	+	+	+	+	+	+	+	+
	steelhead	+	+	+	+	+	+	+	+	+	+	+	+
	splittail	+	+	+	+	+	+	+	+	+	+	+	+
Channel modifications and reestablishment of riparian communities have the potential to improve water temperature conditions in the Sacramento River and its tributaries.	winter-run	+	+	+	+	+	+	+	+	+	+	+	+
	spring-run	+	+	+	+	+	+	+	+	+	+	+	+
	steelhead	+	+	+	+	+	+	+	+	+	+	+	+
Improvement of fish passage at barriers would improve access to existing habitat and increase survival during up- and downstream migration.	winter-run	+	+	+	+	+	+	+	+	+	+	+	+
	spring-run	+	+	+	+	+	+	+	+	+	+	+	+
	steelhead	+	+	+	+	+	+	+	+	+	+	+	+

Table 9. Summary of Environmental Impacts Related to Listed and Proposed Species (Page 4 of 5)

DELTA REGION

Most CALFED actions focus on the Delta Region; therefore, this section presents the majority of CALFED-related impacts. CALFED actions called for under all alternatives involve substantial changes in the disposition of land and water resources throughout the Bay-Delta river system. Part of the Delta agricultural land currently protected by levees would be converted to aquatic habitat (permanently wetted acreage) or to periodically flooded riparian and wetland acreage. Additional short-duration, high spring flow would be allowed to pass down the rivers and through the Delta without being stored, diverted, or exported. A greater proportion of the water being diverted or exported from the system would be passed through fish screens; the toxicant load entering the system from agricultural acreage, abandoned mines, industrial facilities, and other sources would be reduced relative to the No Action Alternative; and a large-scale effort to control the spread of water hyacinth and other invasive non-native plant species would be undertaken.

Developing and implementing dredging guidelines, implementing plans to reduce erosion attributable to boat wakes, and restoring aquatic and adjacent terrestrial and wetland communities would restore natural processes affecting sediment input and movement and would benefit Delta organisms. Reducing contaminant input may increase species survival and rehabilitate biological processes, including processes affecting productivity. Contaminant input and movement may be reduced by source control and treatment of mine drainage to reduce heavy metals emissions and through incentives to reduce emissions of contaminants in urban and industrial runoff, wastewater treatment plant discharge, and nonpoint discharges.

Beneficial impacts are likely to result from reconstructing aquatic and adjacent communities in the Delta. New habitat could reestablish the natural structural characteristics of the Delta, reestablish connections between terrestrial and aquatic habitats, and increase productivity through increased primary production and input of organic carbon. Spawning and rearing habitat availability may be markedly increased for species resident in the Delta, such as delta smelt, splittail, Sacramento blackfish, Sacramento squawfish, tule perch, largemouth bass, and white catfish. Anadromous species, such as striped bass, chinook salmon, steelhead, American shad, and white sturgeon, also may benefit from the availability of additional juvenile rearing and adult habitat.

Fish screens on agricultural diversions, constructed under all alternatives would result in beneficial impacts on juvenile and adult life stages of most Delta fish species relative to conditions under the No Action Alternative. Fish screens on a new Clifton Court Forebay intake under Alternatives 1B and 1C and under Alternatives 1 and 2 would decrease predation losses of all Delta species because fish would be salvaged prior to entry into the forebay.

Newly created habitat, however, may increase the abundance and distribution of carp, inland silversides, or other non-native species that adversely affect the abundance and distribution of native species through competition or predation. Construction activities associated with implementation of some Water Quality, Ecosystem Restoration, and Delta Levee System Integrity Program actions may result in local, short-term adverse impacts on water quality resulting from temporary increases in soil erosion and sediment. The process of restoring marsh and riparian communities may temporarily increase contaminant concentration and cause potentially significant adverse impacts on aquatic species using the marsh or adjacent areas.

The Ecosystem Restoration Program includes actions that would reduce the influx of non-native aquatic species from ship ballast water, directly control populations of non-native species, improve hatchery practices, reduce predator habitat, improve fish passage at barriers, restore habitat diversity and complexity for native species, and improve harvest management. The actions may decrease the adverse impacts associated with human-induced levels of competition, predation, and disease and increase support of self-sustaining native and naturally produced aquatic species populations.

The Water Use Efficiency Program is expected to result in significant benefits to fisheries and aquatic resources. These may include reduced entrainment and impingement impacts associated with diversions, modifications in flow timing and reservoir releases, improved instream water quality, and water transfers directly for ecosystem purposes. Potential adverse impacts may occur if efficiency improvements result in less water available to indirect downstream uses, such as Delta outflow and wetlands and riparian habitats in drains.

Water use efficiency improvements that can result in reduced diversions can allow water to remain in source streams for ecosystem benefits. This can provide improved flow conditions for a reach of stream previously by-passed because of diversions.

Water Transfers would affect fisheries and aquatic resources primarily through changes to riverine flow and water temperatures. Several factors including the source of water for a transfer, the timing, magnitude, and pathway of each transfer have a tremendous effect on the potential for significant impacts. To the extent that transfers are made directly for ecosystem purposes, fisheries and aquatic ecosystems will be beneficially impacted. Significant adverse impacts may result from transfers between agricultural and urban uses if proper planning and management of specific transfers is not undertaken.

Water transfer impacts may be offset by fallowing crops, reduced agricultural water needs, groundwater substitutions, or water conservation, which may increase the volume of water available to provide environmental benefits by increasing outflow, reducing exports, and reducing entrainment. Increased inflow and outflow during specific months may be sufficient to provide beneficial impacts through improved conditions that approximate natural seasonal flow and salinity patterns.

Increasing the volume of water available by these strategies (fallowing, reduced applied water, groundwater substitution) can result in changes in agricultural runoff-related streamflows (including drain flows) elsewhere in the system, affecting habitat on those streams. In can also affect habitat supported by sub-irrigation and surface seepage of groundwater. In addition, fallowing can affect food available to migratory waterfowl.

Adverse impacts of exports under Alternative 1 would continue, and additional exports under Alternative 1C; Alternative 2; and Alternatives 3A, 3B, and 3H would increase entrainment loss of Delta productivity and nutrients. The primary species adversely affected by increased diversions and associated entrainment losses include egg and larval striped bass, delta smelt, longfin smelt, and splittail.

Reduced outflow would shift X2 and the distribution of associated organisms upstream. Adverse impacts could include reduced habitat and increased exposure of organisms to entrainment in Delta diversions.

Under Alternatives 1B, 1C, 2A, 2B, 3A, and 3B, barriers in the south Delta would partially block upper Old River, Grant Line Canal, and part of Middle River. Potentially significant adverse impacts include reduced connectivity to other Delta channels and deterioration of water quality conditions from periodic low dissolved-oxygen levels. Although closure of the Old River barrier may increase survival of juvenile chinook salmon migrating down the San Joaquin River in April and May, adverse species-specific impacts include increased entrainment, interruption of migration toward downstream habitats in the lower Delta and in the Bay, and increased loss of planktonic organisms that are prey for many Delta fish species. Potentially affected species include juvenile chinook salmon, larval and juvenile delta smelt and striped bass, and juvenile splittail.

Construction of an intertie and a new Clifton Court intake under Alternatives 1B and 1C; Alternative 2; and Alternatives 3A, 3B, and 3H may adversely affect Old and Middle rivers flow patterns and associated ecosystem processes, including sediment and nutrient movement and loss of productivity.

Under Alternatives 2 and 3, beneficial impacts of increased cross-Delta flow and subsequent increase in QWEST may include improved survival of organisms moving from the lower San Joaquin River and toward Suisun Bay. Adverse impacts may include reduced productivity in the east and central Delta attributable to reduced residence time. Under Alternative 2, increased cross-Delta flow would reduce residence of water in the east, central, and south Delta, reducing productivity and increasing entrainment of organisms and nutrients.

When Delta outflow is relatively low (for example, from August through October) and diversion of cross-Delta flow under Alternatives 2 and 3 substantially reduces net Sacramento River flow downstream of Georgiana Slough, the resulting conditions may shift X2 farther into the Delta. Location of X2 farther upstream in the Delta potentially exposes organisms associated with X2 to entrainment in Delta diversions.

Reconstruction of several thousand additional acres of aquatic areas in the Delta would occur under Alternatives 2D, 2E and 3H and would substantially add to aquatic habitat reconstructed under the Ecosystem Restoration Program. The reconstructed areas may provide spawning and rearing habitat for delta smelt, splittail, and other Delta species.

Under Alternatives 2A, 2B, and 2D existing unique, high-quality shallow-water, riparian, and SRA habitats in the Snodgrass Slough natural area and adjacent areas would be eliminated or modified by construction and operation of the through-Delta conveyance. Setback levees and erosion of the channel islands also may destroy existing spawning and rearing habitat along Mokelumne River channels. The loss or change in habitat under Alternatives 2A, 2B, and 2D could adversely affect spawning and rearing success of Delta species.

The screened through-Delta facility on the Sacramento River in Alternatives 2A, 2B, and 2D would attract upstream migrating adult anadromous fish into the Mokelumne River channels. Losses from disorientation and migration delay may affect chinook salmon, steelhead, striped bass, American shad, and sturgeon.

The increased proportion of Sacramento River flow diverted into Georgiana Slough and the new Hood and Tyler Island intake facilities under Alternatives 2 and 3 would increase movement of downstream migrants into Georgiana Slough, Mokelumne River channels, and the central Delta. The increased movement could significantly adversely affect survival of downstream migrant juvenile chinook salmon and steelhead, egg and larval striped bass, larval and juvenile American shad, and other outmigrating species. Reduced net flow in the Sacramento River channel also could increase settling of striped bass eggs and larvae, adversely affecting striped bass survival.

Increased flow in the lower San Joaquin River and toward Suisun Bay (QWEST) under Alternatives 2 and 3 may reduce entrainment of species with planktonic life stages and species dependent on flow cues for movement to downstream habitat. Species likely to benefit include juvenile chinook salmon and larval and juvenile delta smelt and striped bass in the lower San Joaquin River.

The substantial reduction in exports from the south Delta under Alternative 3 would reduce entrainment loss of nutrients and organisms. Beneficial impacts of reduced entrainment and increased residence time in Mokelumne River channels and in the east, central, and south Delta may include increased productivity. Reduction of south-Delta exports would substantially reduce entrainment of delta smelt, striped bass, splittail, chinook salmon, and other species that spawn and rear in the central and south Delta.

The Sacramento River diversion point constructed under Alternative 3 may cause significant adverse impacts on species entering the Delta with Sacramento River flow, including juvenile chinook salmon, striped bass, American shad, and splittail. Egg and larval life stages cannot be effectively screened, and the isolated facility intake would increase entrainment loss of striped bass eggs and larvae, and splittail larvae transported with Sacramento River flow.

Alternative 3I includes three new intake locations along the San Joaquin River and in the central Delta that could increase entrainment loss of fish in the lower San Joaquin River and the central Delta.

ALTERNATIVE 1

Alternative 1 consists of three Configurations (1A, 1B, and 1C) that implement the CALFED programs (Table 10). Relative to the No Action Alternative, diversions and reservoir operations under Alternative 1 would be altered to meet the flow needs identified in the Ecosystem Restoration Program. Diversions and reservoir operations are also different because of changes in the export facilities (Alternatives 1B and 1C) and increased storage north and south of the Delta (Alternative 1C). Alternatives 1B and 1C would include SWP and CVP fish screens and an intertie, an operable Old River barrier, and the south-Delta barriers (Figure 2). New storage north and south of the Delta, Old River enlargement, and use of full SWP pump capacity are specific to Alternative 1C.

Ecosystem-Level Impacts

Flow

Operations rules and demands, and Delta channel structure would be similar under Alternative 1 and the No Action Alternative. Under Alternative 1, Delta inflow and outflow and the associated salinity distribution would be similar to conditions under the No Action Alternative.

Under Alternatives 1A and 1B, average annual exports would increase by 47 TAF (1%) relative to the No Action Alternative. The frequency of high export levels would increase during January and February. Under Alternative 1C, south-Delta modifications would relax current regulatory constraints and allow the export pumps to operate to their physical capacity. Enlarged upstream storage capacity would augment water available for export. Average annual exports would increase by an average of 556 TAF (9%) relative to the No Action Alternative, primarily from February through May (Table 11).

Adverse effects of exports under the No Action Alternative would continue and additional exports would increase entrainment loss of Delta productivity and nutrients. Under Alternative 1, net flow of Old and Middle rivers would continue toward the SWP and CVP export facilities, and flow conditions would be opposite those of the natural condition—net flow toward Suisun Bay. Alternative 1C would substantially increase the movement of Sacramento River flow toward the export facilities, and increase entrainment loss of Delta productivity and nutrients.

Ecosystem Restoration Program actions that reestablish naturally occurring short-term flow increases would be implemented under all alternatives (Table 12) and require evaluation at a greater level of detail than is available for this impact assessment. The flow-related actions would result in beneficial impacts on sediment and nutrient input and movement, productivity, and channel maintenance. Impacts of short-term flow events will require evaluation prior to implementation of specific program actions.

Under Alternative 1A, Delta channel structure would be the same as that under the No Action Alternative and existing conditions. Structural changes in the Delta under Alternatives 1B and 1C (the head-of-Old-River barrier and south-Delta barriers) would have a minimal effect on flow in most of the Delta channels relative to the No Action Alternative; however, the barriers would substantially change San Joaquin River flow downstream of the head of Old River, head of Old River flow, Old and Middle rivers flow, and flow conditions in the channels contained within the south-Delta barriers (Figure 2).

Most San Joaquin River inflow, under both the No Action Alternative and Alternative 1, would be entrained in Delta island diversions and exports (Table 13). Under Alternatives 1B and 1C, the pathway of San Joaquin River inflow would change. With the Old River and south-Delta barriers, flow in the San Joaquin River past Stockton would increase and flow down the head of Old River would decrease (Table 14). Although the fate of San Joaquin River water would be the same under both the No Action Alternative and Alternative 1, the longer residence in the Delta under Alternatives 1B and 1C (Table 15) is attributable to the longer pathway to the south-Delta export facilities and diversions. The changes would affect conditions in the San Joaquin River and south Delta from April through November. Beneficial impacts may include increased productivity, although entrainment of organisms and nutrients under Alternatives 1B and 1C would be similar to that under the No Action Alternative. Net flow in Old and Middle rivers would increase toward the SWP and CVP export facilities (Table 16) and would reduce residence time in those channels (Table 15); however, entrainment of water and associated nutrients and planktonic organisms in Old and Middle rivers in south-Delta diversions would be similar to that under the No Action Alternative. Impacts of the head-of-Old-River barrier also would occur under Alternatives 2 and 3. Impacts of the south-Delta barriers would occur under Alternatives 2A, 2B, 3A, and 3B.

Construction of an intertie under Alternatives 1B and 1C and Alternatives 2 and 3 would allow for operational flexibility to shift diversions between the existing Tracy intake to Clifton Court. Increased operational flexibility may result in beneficial impacts on flow patterns. The existing Clifton Court intake has a capacity of approximately 15,000 cubic feet per second (cfs), however, the intake with the south-Delta improvements and the intertie would add a Clifton Court intake with 30,000-cfs capacity. The operation of the new intake, in conjunction with the intertie, could adversely affect flow patterns and associated ecosystem processes, including sediment and nutrient movement and loss of productivity. Available information is insufficient to evaluate short-term effects of Clifton Court intake operations. A monitoring program should be implemented to determine both physical and biological effects of operations with the increased capacity. If monitoring indicates significant adverse impacts, mitigation could include returning to existing conditions (operations without the intertie and limited Clifton Court intake capacity), using the full flexibility in the operation of the intertie and the new intake.

Water Temperature

In general, water temperature conditions under all alternatives most likely would be similar to conditions described under the No Action Alternative. Inflows affect only the temperature just below reservoirs, and ambient air temperature primarily determines water temperature in the lower reaches of the Sacramento River and the Delta.

The Ecosystem Restoration Program includes some actions affecting water temperature under all alternatives. The actions likely would not affect the entire Delta but may affect specific sections of some channels. Reducing the volume of return flows and M&I discharge would reduce water temperature effects of discharged flows. Additionally, restoring riparian and SRA communities along Delta channels would provide local areas of temperature refuge. Restoring shallow water habitat, however, may provide areas with greater temperature variability relative to water temperature in the existing, relatively deeper channels.

Sediment and Nutrient Input and Movement

Actions affecting sediment and nutrient input and movement under Alternative 1 primarily would be those in the Ecosystem Restoration Program. The effects of flow changes on sediment and nutrient input and movement from the frequency of floodplain inundation and flow velocity changes would be minimal under Alternative 1 relative to the No Action Alternative. High flow that would mobilize nutrients and sediments would be similar to flow under the No Action Alternative. As discussed above, barriers in the south Delta would cause the nutrient-rich San Joaquin River to flow down the San Joaquin River past Stockton and south through Old and Middle rivers toward the SWP and CVP export facilities. The entrainment of flow in Delta exports and island diversions would be similar to entrainment under the No Action Alternative, and the net effect on Delta productivity most likely would be minimal.

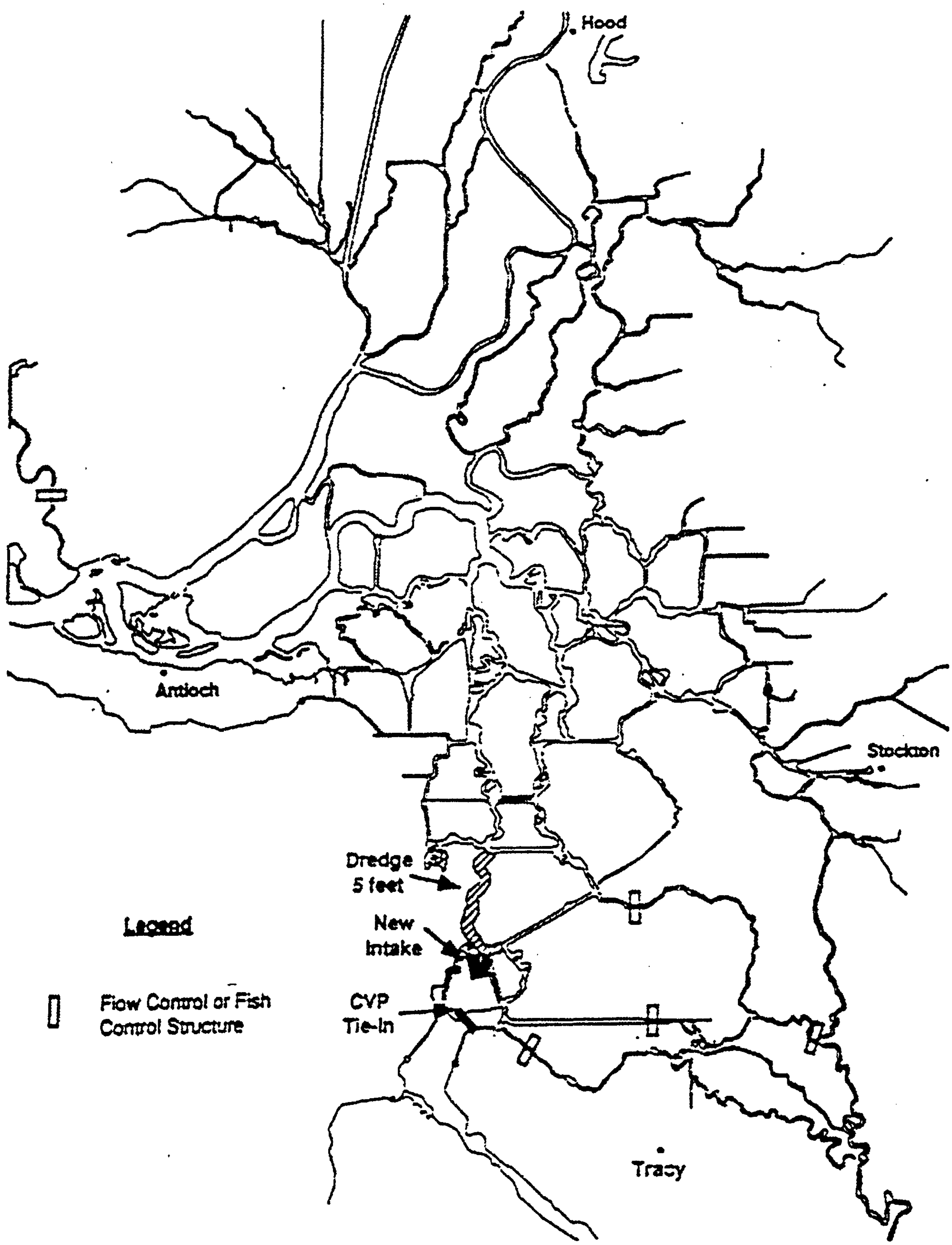

Figure 2. Assumed Location of the South-Delta Barriers

CALFED Action	Alternatives											
	1A	1B	1C	2A	2B	2D	2E	3A	3B	3E	3H	3I
Conveyance Program Actions:												
SWP and CVP fish screens and intertie		X	X	X	X	X	X	X	X	X	X	X
SWP full physical pump capacity			X	X	X	X	X	X	X	X	X	X
Operable Old River barrier		X	X	X	X	X	X	X	X	X	X	X
South-Delta barriers		X	X	X	X			X	X			
Through-Delta intakes[a]				H	H	H	D				D	
Three new SWP and CVP intakes												X
Delta island flooding[b]						10	20				20	
Isolated facility[c]								5	5	15	5	15
Storage Program Actions[d]:												
Sacramento River Region			3.5		3.5		3.5		3.5	3.5	3.5	3.5
San Joaquin River Region					0.5		0.5		0.5	0.5	0.5	0.5
Delta Region			1.5		2.5	2.0	2.5		2.7	2.7	2.5	2.6

NOTES:

"X" or other symbols indicate that the actions would be implemented for the designated Alternative.

[a] Through-Delta intakes include: H = 10,000-cfs capacity screened intake at Hood; D = unspecified capacity, unscreened intake, near existing Delta Cross Channel.

[b] Delta island flooding is separate from aquatic acreage reestablished under the Ecosystem Restoration Program: 10 = 5,000 to 10,000 acres; 20 = 10,000 to 20,000 acres.

[c] Isolated facility with a screened intake near Hood and additional Delta Cross Channel closure September to June; 5 = 5,000-cfs capacity; 15 = 15,000-cfs capacity.

[d] Storage in million acre-feet; the location indicates the region directly affected by filling of the storage facility.

Table 10. Summary of Variable CALFED Actions Included in All Alternatives

Alternative	Variability in Exports Attributable to Operations and Facility Changes (%)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No Action												
Frequency below low range[a]	19	19	15	8	10	14	40	26	12	15	15	18
Frequency above high range[b]	34	5	11	51	42	45	0	3	18	44	59	27
1A, 1B												
Frequency below low range[a]	19	19	15	5	8	14	38	27	12	14	15	15
Frequency above high range[b]	32	10	11	59	53	40	0	3	19	42	62	29
1C												
Frequency below low range[a]	16	19	16	11	8	12	41	25	12	19	14	10
Frequency above high range[b]	37	42	56	68	63	58	8	15	19	53	19	26
2A												
Frequency below low range[a]	19	23	21	12	19	18	40	27	12	14	14	16
Frequency above high range[b]	36	41	59	53	22	19	8	15	19	64	37	29
2D												
Frequency below low range[a]	23	21	10	40	19	12	22	12	10	26	21	21
Frequency above high range[b]	37	41	53	66	38	49	8	15	19	64	60	29
2B, 2E												
Frequency below low range[a]	19	23	21	11	8	10	41	25	16	15	12	14
Frequency above high range[b]	33	41	52	67	53	52	10	15	19	70	63	21
3A												
Frequency below low range[a]	26	26	21	14	18	15	40	27	11	15	14	16
Frequency above high range[b]	36	40	58	53	22	19	8	15	19	64	36	27
3B, 3H												
Frequency below low range[a]	22	25	16	11	5	8	36	22	16	16	14	18
Frequency above high range[b]	32	41	51	64	41	56	8	18	25	70	58	22
3E, 3I												
Frequency below low range[a]	25	29	21	14	10	11	41	25	16	15	14	19
Frequency above high range[b]	38	45	58	63	32	45	8	16	26	68	55	47

NOTES:

[a] Low range is the average export for existing conditions minus 1 standard deviation or the minimum export, whichever is largest.

[b] High range is the average export for existing conditions plus 1 standard deviation or the maximum export, whichever is smallest.

SOURCES:
DWRSIM, CALFED 1997a.

Table 11. Percent Variability in Exports Attributable to Operations and Facility Changes under All Alternatives

C-008119

Ecosystem Restoration Program Action	Minimum Data Needed to Assess Impacts	Potential Source of Data
Emulate natural seasonal Delta outflow pattern	Monthly Delta outflow	DWRSIM
10-day flow event in March on the Sacramento, Feather, and American rivers	Monthly flow[a]	DWRSIM
Flow event from April through May on the Merced, Tuolumne, Stanislaus, San Joaquin, and Mokelumne rivers	Monthly flow[a]	DWRSIM
First fall or early winter storm flow event	Daily flow	Not available
Minimum Sacramento River flow of 13,000 cfs at Freeport in May	Monthly flow	DWRSIM
Minimum net lower San Joaquin River flow near the mouth of Old River	Monthly flow	DWRDSM
Reestablish more natural internal Delta hydraulics	Monthly flow	DWRDSM
Late-winter or early spring flow event below Keswick	Daily flow	Not available
Maintain minimum base flows on the Sacramento, Feather, American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers	Monthly flow	DWRSIM
Maintain small tributary flow	Daily flow	Not available
Emulate natural frequency of overbank and floodplain inundation	Daily flow	Not available
Provide flows to maintain native species below Friant	Daily flow	Not available

NOTES:

cfs = cubic foot per second.

[a] Daily flow data may be required to fully evaluate potential effects.

Table 12. Flow-Related Actions Included in the Ecosystem Restoration Program

	Entrainment of Mass Introduced at Discrete Delta Locations (%)											
	Exports						Island Diversions					
Injection Location	1A	1C	2B	2D	2E	3E	1A	1C	2B	2D	2E	3E
Vernalis												
February 1979	88	88	88	82	83	11	0	1	1	0	0	1
April 1981	77	76	78	70	73	0	10	8	8	7	7	8
October 1989	92	81	82	76	76	11	7	9	8	8	9	10
July 1991	31	4	5	22	22	20	61	69	70	68	68	69
Freeport												
February 1979	1	1	0	0	1	37	0	0	0	0	0	0
April 1981	5	8	3	3	7	51	3	3	2	2	4	2
October 1989	42	43	15	12	35	63	5	5	5	5	4	4
July 1991	4	6	6	1	0	25	26	26	23	14	19	20
Rio Vista												
February 1979	0	0	0	0	0	0	0	0	0	0	0	0
April 1981	2	3	1	1	1	0	1	1	1	1	1	1
October 1989	17	19	10	12	13	1	2	2	2	2	2	2
July 1991	2	3	3	1	0	1	8	8	8	8	11	8
Jersey Point												
February 1979	1	1	0	1	0	0	0	0	0	0	0	0
April 1981	8	13	3	6	3	0	3	3	2	2	1	2
October 1989	38	41	20	26	29	2	3	2	2	2	2	2
July 1991	6	8	6	4	3	2	9	8	8	8	7	8
Prisoners Point												
February 1979	10	11	10	10	7	0	0	0	0	0	0	0
April 1981	47	56	52	40	40	0	4	5	4	3	3	3
October 1989	92	91	88	88	89	3	3	3	3	3	3	3
July 1991	30	35	36	15	15	7	21	21	21	18	17	17
Old River at Rock Slough												
February 1979	88	89	87			21	1	1	1			0
April 1981	50	61	58			1	39	32	33			14
October 1989	90	92	91			83	8	7	7			7
July 1991	71	71	70			74	24	25	26			19
Snodgrass Slough												
February 1979	4	5	1			0	0	0	0			0
April 1981	1	6	19			0	15	15	4			30
October 1989	78	79	68			0	5	5	3			28
July 1991	12	16	15			2	24	24	23			28

SOURCES:
DWRDSM studies, CALFED 1997b.

Table 13. Entrainment of Mass Introduced at Discrete Delta Locations for Alternatives

In the Delta, beneficial impacts result from actions to restore and maintain sediment supply, deposition, and transport. Potential actions include developing and implementing dredging guidelines; implementing plans to reduce erosion attributable to boat wakes; and restoring aquatic and adjacent terrestrial and wetland communities, including riparian, SRA, shallow water, channel islands, and tidal marsh. Restoring shallow-water vegetated areas would increase settling of suspended sediments, potentially reducing water depth along channel margins. Additionally, restoring sediment and nutrient input and movement processes in areas upstream of the Delta would contribute to restoration of similar processes in the Delta.

Contaminant Input and Movement

The primary actions affecting contaminant input and movement under all alternatives would be those in the Ecosystem Restoration and Water Quality programs. In the Delta, actions with beneficial impacts are directed primarily at reducing inputs, including runoff of copper, zinc, cadmium, pesticides, nutrients, and sediment. Actions in the Water Quality Program would reduce heavy metals emissions through source control and treatment of mine drainage; emissions of contaminants in urban and industrial runoff and in wastewater discharges through enforcement of existing regulations; and nonpoint discharges, including emissions of contaminants in agricultural surface runoff and subsurface drainage, through provision of incentives. Although contaminant input may be reduced relative to the No Action Alternative, urban and industrial growth would increase contaminant input under all alternatives relative to existing conditions. Construction activities associated with implementation of some Water Quality, Ecosystem Restoration, and Delta Levee System Integrity program actions may result in local, short-term adverse impacts on water quality from temporary increases in soil erosion and sediment and contaminant emissions. Examples of these actions are retrofitting drainage systems, constructing levees, and restoring habitat. Construction-related impacts can be reduced to less-than-significant levels by applying conventional construction-site mitigation measures.

Contaminants in the Sacramento and San Joaquin rivers and their tributaries eventually enter the Delta. Actions that address contaminant input and movement upstream of the Delta also would benefit the Delta ecosystem. In addition to actions identified for the Delta, improved source control and treatment of mine drainage; reduced scour of metal-laden sediments; and actions addressing watershed management, including land use practices, would reduce movement of contaminants into the Delta system.

Contaminants in the Sacramento and San Joaquin rivers undergo a variety of processes before and after they reach the Delta. Many pesticides break down into nontoxic compounds in a relatively short period of time. Some persistent pesticides, such as dichlorodiphenyltricholoroethane (DDT) and dichlorodiphenyldicholorethylene (DDE), remain in the sediments for decades and reenter the food chain when they are disturbed by dredging or biological activity. Habitat restoration activities may mobilize a variety of heavy metals and persistent pesticide residues during construction and maintenance activities. Many heavy metals, such as selenium and mercury, and some pesticides are actively concentrated by the metabolic activity of microorganisms in the aquatic ecosystem of the Delta. Fish and other aquatic organisms may bioaccumulate metals and pesticides in their tissues, resulting in reproductive disfunction, morbidity, or death. Mercury is of particular concern in this respect. Some species of bacteria found in Delta sediments convert relatively nontoxic metallic mercury into a methylated, highly toxic form that enters the food chain and accumulates in fish and other aquatic organisms and their predators.

Restoring marsh and riparian communities provides increased opportunity for biologically processing nutrients and capturing sediments entering the Delta in urban and agricultural discharges and runoff, benefitting organisms in the Delta and Bay. Under certain conditions, a restored marsh receiving contaminated discharge may become unsuitable habitat because of cumulative increases in contaminant concentration that cause significant adverse impacts on aquatic species using the marsh or adjacent areas. For example, mercury methylation may take place in some restored marshes and accelerate the process of bioaccumulation of mercury in aquatic organisms. Monitoring and mitigation programs should be incorporated into restoration of marsh communities receiving contaminated discharge or with existing relatively high levels of contaminated sediments. Monitoring should focus on detecting cumulative increases in contaminant concentration and the potential for accumulation, magnification, and transformation by aquatic organisms. The mitigation would include potential actions to reduce or eliminate input of contaminants adversely affecting the aquatic environment.

Productivity

Aquatic foodweb productivity in the Delta has declined over the past several decades. The decline is attributed to changes in freshwater inflow, Delta channel hydraulics (altering residence time), water diversions, water quality, and species composition of aquatic communities. Productivity would be affected by the impacts identified for the processes discussed above and from changes in structural characteristics described below. Under existing conditions, Delta diversions export a large portion of the nutrients and detrital load that support the Delta foodweb. Current flow patterns through the Delta and location of the diversion facilities in sensitive areas of the Delta result in losses of important nutrients and foodweb organisms. Spring flow events in the Delta deliver essential nutrients and increase productive shallow-water and wetland habitat. sloughs and adjacent marsh habitat. Restoration would reestablish connections between terrestrial and aquatic habitats, and would increase productivity through increased production and input of organic carbon. Restored habitat in areas upstream of the Delta also would contribute to increased productivity in the Delta. Although losses of productivity to Delta exports and island diversions would continue, overall Delta productivity most likely would increase relative to existing conditions and the No Action Alternative and result in a beneficial impact on the Delta ecosystem.

Structural Characteristics

Flow effects on productivity in the Delta were discussed above under "Flow." Flow conditions under Alternatives 1A and 1B would be similar to conditions under the No Action Alternative. Under Alternative 1C, exports would substantially increase relative to the No Action Alternative and contribute to ongoing significant adverse impacts of entrainment of Delta productivity.

Increased productivity is likely to result from restoration of aquatic and adjacent communities The Delta was once a vast tule marsh with an interconnecting maze of riparian-lined sloughs and channels; it currently consists of reclaimed farmland protected from flooding by an in the Delta under the Ecosystem Restoration Program, including floodplain, tidal perennial aquatic habitat, nontidal perennial aquatic habitat, Delta sloughs, midchannel islands and shoals, fresh emergent wetland, seasonal wetland, and riparian and SRA habitat. Setback levees in some areas of the Delta would expand extensive levee system. Remnant tule marshes are found on small channel islands or along the shorelines of the remaining sloughs and channels. Habitat restoration actions included in the Ecosystem Restoration Program would restore some of the natural structural characteristics of the Delta. Actions include restoring aquatic and adjacent communities, including floodplain, tidal perennial aquatic habitat, nontidal perennial aquatic habitat, Delta sloughs, midchannel islands and shoals, fresh emergent wetland, seasonal wetland, and riparian and SRA habitat. Restoration of aquatic habitat, potentially several thousand acres, may result from breaching levees and flooding existing agricultural lands and from setting levees back along existing Delta channels. Changing levee maintenance practices to allow development of natural riparian and marsh communities also may restore structural characteristics of the Delta.

Alternative	Variability of Net Old River Flow Attributable to Head-of-Old-River Barrier (%)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1A												
Frequency below low range[a]	0	0	0	0	0	0	0	0	0	0	25	0
Frequency above high range[b]	13	13	13	19	19	13	19	19	6	6	19	13
1C												
Frequency below low range[a]	88	88	6	6	6	6	56	81	56	31	81	63
Frequency above high range[b]	13	13	13	19	19	13	19	19	6	6	0	6
2B												
Frequency below low range[a]	88	88	6	6	6	6	56	81	56	31	81	63
Frequency above high range[b]	13	13	13	19	19	13	19	19	6	6	0	6
2D												
Frequency below low range[a]	88	88	19	6	6	6	56	81	13	6	31	25
Frequency above high range[b]	13	13	13	19	19	13	19	19	6	6	0	13
2E												
Frequency below low range[a]	88	88	19	6	6	6	56	81	13	13	31	25
Frequency above high range[b]	13	13	13	19	19	13	19	19	6	6	0	13
3E												
Frequency below low range[a]	88	88	25	31	6	13	56	81	44	31	50	44
Frequency above high range[b]	13	13	13	19	19	13	19	19	6	6	0	6

NOTES:

[a] Low range is the average flow for Alternative 1A conditions minus 1 standard deviation or the minimum flow, whichever is largest.

[b] High range is the average flow for Alternative 1A conditions plus 1 standard deviation or the maximum flow, whichever is smallest.

SOURCES:
DWRDSM studies, CALFED 1997b.

Table 14. Percent Variability of Net Old River Flow Attributable to the Head-of-Old-River Barrier under Alternatives

Injection Location	Residence of Mass Introduced at Discrete Delta Locations (%)											
	10 Days after injecting						30 Days after injecting					
	1A	1C	2B	2D	2E	3E	1A	1C	2B	2D	2E	3E
Vernalis												
February 1979	28	29	28	37	36	88	7	7	4	8	5	9
April 1981	32	72	70	94	93	96	13	16	13	21	17	83
October 1989	2	95	95	95	95	95	1	10	10	15	15	78
July 1991	11	44	44	38	38	39	6	26	25	10	10	11
Freeport												
February 1979	17	17	30	31	31	6	1	1	23	24	3	0
April 1981	75	75	90	89	97	44	23	19	40	41	34	7
October 1989	94	92	95	96	98	33	32	31	66	68	52	27
July 1991	85	85	90	92	89	64	59	57	61	77	78	49
Rio Vista												
February 1979	4	4	1	1	1	1	0	0	0	0	0	0
April 1981	53	53	64	63	77	62	10	9	4	4	4	3
October 1989	89	88	96	96	95	96	38	36	52	50	47	59
July 1991	94	94	94	95	95	95	55	54	56	59	66	59
Jersey Point												
February 1979	28	28	6	6	2	6	1	1	0	0	0	0
April 1981	84	81	78	79	70	73	27	24	7	7	3	5
October 1989	84	80	87	89	88	96	37	34	45	42	41	62
July 1991	94	93	93	94	94	94	56	55	55	59	56	58
Prisoners Point												
February 1979	93	92	80	80	66	59	15	13	6	8	4	0
April 1981	98	94	91	97	97	98	43	31	21	33	27	35
October 1989	57	52	48	75	73	99	3	4	6	7	6	91
July 1991	96	96	96	96	96	97	44	38	36	62	61	72
Old River at Rock Slough												
February 1979	34	35	35			66	1	1	0			1
April 1981	20	29	30			89	8	5	5			84
October 1989	5	4	4			22	2	1	2			9
July 1991	11	10	10			15	4	3	4			5
Snodgrass Slough												
February 1979	91	91	40			97	7	6	1			1
April 1981	90	90	96			77	82	77	24			66
October 1989	90	85	80			84	15	14	23			72
July 1991	90	90	90			87	59	56	57			67

SOURCES:

DWRDSM studies, CALFED 1997b.

Table 15. Residence of Mass Introduced at Discrete Delta Locations for Alternatives

Alternative	Average Percent Variability of Net Flow of Old and Middle Rivers Attributable to Structural Changes in the Delta Channels											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1A												
Frequency below low range[a]	25	25	19	13	19	13	0	13	0	25	19	13
Frequency above high range[b]	25	13	13	13	13	13	13	13	6	13	19	25
1C												
Frequency below low range[a]	38	31	19	13	19	13	38	50	13	31	25	25
Frequency above high range[b]	19	6	13	19	13	13	13	6	6	13	19	19
2B												
Frequency below low range[a]	38	31	19	13	19	13	38	50	13	31	25	25
Frequency above high range[b]	19	6	13	13	13	13	13	6	6	13	19	19
2D												
Frequency below low range[a]	38	31	19	31	19	13	38	50	13	31	25	25
Frequency above high range[b]	19	6	13	19	13	13	13	6	6	13	19	25
2E												
Frequency below low range[a]	38	31	19	31	19	13	38	50	13	31	19	25
Frequency above high range[b]	19	6	13	13	13	13	13	6	6	13	19	25
3E												
Frequency below low range[a]	0	0	0	0	0	0	0	0	0	0	0	0
Frequency above high range[b]	100	100	100	100	44	38	94	100	100	100	100	100

NOTES:

[a] Low range is the average flow for Alternative 1A conditions minus 1 standard deviation or the minimum flow, whichever is largest.

[b] High range is the average flow for Alternative 1A conditions plus 1 standard deviation or the maximum flow, whichever is smallest.

SOURCES:
DWRDSM studies, CALFED 1997b.

Table 16. Average Percent Variability of Net Flow of Old and Middle Rivers Attributable to Structural Changes in the Delta Channels by Alternative

Under Alternatives 1B and 1C, barriers in the south Delta are included in the conveyance component. Barriers would adversely affect the structural characteristics of the south Delta because the barriers would partially block upper Old River, Grant Line Canal, and part of Middle River, reducing the connection to the rest of the Delta for part of the year. The barriers would affect channel connections from April to November each year. Flow effects of the structural changes were described above (see "Flow"). Additional flow effects in the channels confined by the barriers include reduced tidal and net flow (CALFED 1997b). Potential adverse impacts include reduced connectivity to other Delta channels and deterioration of water quality conditions from periodic low dissolved oxygen levels. Mitigation could include restoring equivalent areas through setting levees back and flooding islands in the south and central Delta.

Structural changes that affect Delta volume and channel structure potentially affect tidal flow that in turn affects X2 location. Flooding Delta islands under the Ecosystem Restoration Program would affect Delta channel structure. Flooding Delta islands under Alternatives 2E and 3H; setting levees back; and dredging channels also would affect Delta channel structure. An upstream shift in X2 could increase entrainment of Delta species. The effect of structural changes on tidal flow and X2 location requires information on channel and island cross sections that will need to be developed for site-specific actions.

Species-Specific Impacts

Habitat

The conversion of Delta islands from agricultural use to inundated wetlands and open-water habitat under the Ecosystem Restoration Program would markedly increase the abundance of aquatic habitat for Delta species under all alternatives. Under full implementation of the Ecosystem Restoration Program, the extent of permanently inundated acreage in the Delta would increase by several thousand acres. Some of this newly created surface acreage would be shallow and bordered by wetlands or other frequently flooded edge habitat. Some of the acreage would be deep water, with shoals and channel islands.

The habitat value of newly inundated areas for Delta species would vary greatly, depending on the location and morphological characteristics of the restored areas. If reestablished areas were located close to export facilities, were isolated from existing aquatic habitat, or provided depth or salinity unsuitable for important Delta species, the habitat value may be minimal. Under the existing Delta configuration, habitat reconstructed in the south Delta would have the least value to Delta species because of proximity to Delta diversions, including the SWP and CVP export facilities. Production from the restored habitat would be subject to entrainment in diversions and loss from the ecosystem. Reconstructed habitat in the central Delta also would be of minimal value, primarily because of the effects of diversion and export but also because setting levees back and flooding Delta islands would create mostly deepwater habitat. More extensive actions that reduce water depth and increase channel complexity could increase the habitat value.

Reestablished habitats in the north Delta are more distant from the export facilities, potentially include shallower habitat that would incorporate greater channel complexity, and are closer to existing habitats that more closely emulate natural Delta conditions. Additionally, production from north-Delta habitat is more likely to contribute to production in habitats downstream in Suisun Marsh and the Bay.

Because the location of reconstruction and the characteristics of the flooded habitat are not known, it is difficult to assess the benefits to individual Delta species. New spawning and rearing habitat may be provided for species resident in the Delta, such as delta smelt, splittail, Sacramento blackfish, Sacramento squawfish, tule perch, largemouth bass, and white catfish. Anadromous species, such as striped bass, chinook salmon, steelhead, American shad, and white sturgeon, also may benefit from the availability of additional juvenile rearing and adult habitat; however, newly created habitat also may increase the abundance and distribution of carp, inland silversides, or other non-native species that compete with or prey on native species and species with higher economic and social value (chinook salmon, delta smelt, and striped bass).

Ecosystem flow effects were described above and include, for Alternative 1C, adverse effects on flow conditions in the south Delta relative to the No Action Alternative and continuance of the degraded flow pattern relative to natural conditions. Old and Middle rivers would flow toward the SWP and CVP export facilities for all Configurations of Alternatives 1 and 2. Increased Delta exports would increase loss of planktonic organisms that are prey for many Delta fish species, further degrading rearing habitat conditions. Larvae and juveniles of species that feed on planktonic organisms, including striped bass and delta smelt, most likely would be most affected.

The south-Delta barriers, constructed under Alternatives 1B, 1C, 2A, 2B, 3A, and 3B, would adversely affect habitat confined within the barriers from April through November, including reduced connectivity to other Delta channels and deterioration of water quality conditions, such as periodic low dissolved oxygen levels. Adversely affected species could include juvenile chinook salmon, larval and juvenile delta smelt and striped bass, and juvenile splittail. Year-round resident species such as largemouth bass and white catfish also may be adversely affected by deterioration of water quality. Mitigation could include restoring equivalent areas through setting levees back and flooding islands in the south and central Delta.

Water Quality

Water temperature conditions under all alternatives most likely would be similar to conditions under the No Action Alternative (see "Water Temperature" under "Ecosystem-Level Impacts"). Under all alternatives, contaminant inputs would be reduced relative to the No Action Alternative and increase relative to existing conditions (see "Contaminant Input and Movement" under "Ecosystem-Level Impacts"). For this programmatic document, the specificity of information is insufficient to develop impact conclusions for individual species. In general, change in water temperature would affect specific habitat in some Delta channels and could benefit some species. Reducing contaminant input relative to the No Action Alternative most likely would benefit all Delta species, although the pathway and magnitude of the beneficial impact cannot be determined with available information.

Construction activities associated with implementation of some Water Quality, Ecosystem Restoration, and Delta Levee System Integrity program actions may result in local, short-term adverse impacts on water quality, including increased turbidity from temporary soil erosion, sediment and contaminant emissions, and bottom sediment disturbance. Impacts on all Delta species may include increased egg mortality, temporary loss of rearing habitat, and short-term exposure to adverse levels of contaminants. Adverse impacts can be reduced to less-than-significant levels by applying conventional construction-site best management practices.

Entrainment

Ecosystem Restoration Program actions, implemented under all alternatives, include installing fish screens on agricultural diversions. Conveyance modifications under Alternatives 1B and 1C and Alternatives 2 and 3 include improved fish facilities at the SWP and CVP Delta pumps. The actions would reduce fish entrainment and other diversion-related mortality. Fish screens would benefit juvenile and adult life stages of most Delta species relative to conditions under the No Action Alternative. Fish losses would continue to occur at the new screening facilities because of inadequate bypass flow, fish handling, predation, and other associated stressors.

Under all Configurations of all alternatives, entrainment losses associated with ongoing diversions that are not reduced by fish screens would continue. As discussed under the ecosystem level of analysis above, SWP and CVP exports would increase primarily from December through May under Alternative 1C relative to the No Action Alternative (Table 11). All Delta species would be adversely affected, especially species with planktonic life stages. The primary species adversely affected by increased entrainment losses include egg and larval striped bass, delta smelt, longfin smelt, and splittail. Entrainment of planktonic invertebrates (native mysids and rotifers) also would increase.

The intertie between the SWP and CVP facilities under Alternatives 1B and 1C and Alternatives 2 and 3 would increase operational flexibility, including the ability to shift diversions between the existing Tracy intake to Clifton Court. Increased operational flexibility provides the opportunity to reduce entrainment rates; however, the existing Clifton Court intake has a capacity of approximately 15,000 cfs. The intake with the south-Delta improvements and the intertie would add a Clifton Court intake with a 30,000-cfs capacity. The operation of the new intake, in conjunction with the intertie, could increase entrainment rates, especially of life stages that cannot effectively be salvaged. Because available information is insufficient to specifically evaluate short-term entrainment effects of Clifton Court intake operations, a monitoring program should be implemented to determine effects on entrainment. If monitoring indicates a significant increase in entrainment, mitigation could include returning to existing conditions (operations without the intertie and limited Clifton Court intake capacity), using the full flexibility in the operation of the intertie and the new intake.

Water Surface Level

Installing flow and stage control measures on Middle River, Grant Line Canal, and Old River under Alternatives 1B and 1C may increase water surface levels and reduce stage variability in the affected south-Delta channels. The effects of stage changes on fish and motile aquatic resources are expected to be minor; however, effects on vegetation and other wetland resources may be greater (CALFED 1997c). Water surface level impacts would be the same for Alternatives 2A, 2B, 3A, and 3B.

Movement

Under Alternative 1A, conditions affecting movement of species would be similar to conditions under the No Action Alternative. Under Alternatives 1B and 1C, installing south-Delta and head-of-Old-River barriers would affect the movement of species in the south and central Delta.

Installing an operable barrier at the head of Old River in Alternatives 1B and 1C and Alternatives 2 and 3 would reduce flow down Old River (Table 14) and increase flow down the San Joaquin River. Outmigrating fall-run chinook salmon in the San Joaquin River would be blocked from entering Old River during April and May. Although not conclusive, studies indicate that survival of outmigrating juveniles may be higher when there is positive flow down the San Joaquin River past the head of Old River; however, nearly all of the San Joaquin River flow would move south in Old and Middle rivers and be entrained in Delta diversions and exports. Existing data do not clearly indicate that delay in entrainment of San Joaquin River water combined with movement down the San Joaquin River past Stockton would increase survival of San Joaquin River chinook salmon.

The head-of-Old-River barrier and the south-Delta barriers increase Old and Middle rivers flow toward the export facilities from April through November (Table 16). Although effects of increased net flow volume on species rearing in and migrating through the central and south Delta have not been demonstrated, adverse impacts may include interruption of migration toward downstream habitats in the lower Delta and in the Bay. Species with planktonic life stages, such as delta smelt and striped bass, and species that rely on flow-related cues for successful migration toward the Bay (Delta smelt, striped bass, and chinook salmon) would be most affected. Closing the barrier without adequate biological information could result in significant adverse impacts through increased entrainment losses in Delta diversions and exports and inadequate habitat conditions (water quality and prey availability). An operational barrier on Old River may provide the opportunity, based on the results of future studies, to avoid significant adverse impacts and potentially provide benefits to Delta species, in addition to potential improvements to water quality in the San Joaquin River near Stockton. Impacts of increased flow in Old and Middle rivers attributable to south-Delta barriers would be similar for Alternatives 1B, 1C, 2A, and 2B.

Increased exports under Alternative 1C would further increase flow in Old and Middle rivers toward the SWP and CVP export facilities. The increased net flow could result in adverse impacts similar to those described in the preceding paragraph for increased flow attributable to the south-Delta barriers. Additional months would be affected (February through May), potentially coinciding with the primary occurrence of winter- and spring-run chinook salmon in the Delta. Under the existing Delta configuration, impacts of increased southerly flow in Old and Middle rivers that are attributable to increased SWP and CVP exports would be unavoidable.

The installation of flow and stage control measures on Middle River, Grant Line Canal, and Old River in Alternatives 1B, 1C, 2A, 2B, 3A, and 3B could impede fish movement into and out of the areas confined by the barriers from April through November; however, the barriers are partial, and motile species would continue to access the affected habitat. Use of the affected area would depend more on suitable water quality conditions, prey availability, and other environmental factors.

Species Interactions

Although species interactions are a natural part of communities and ecosystems, predation and competition within the Delta have been altered from historical conditions by human-aided introduction of non-native species, stocking of hatchery-reared fish, creation of predator habitat, and construction of barriers that restrict movement.

Losses of juvenile anadromous fish to predation would continue to be high for fish entering Clifton Court Forebay under Alternatives 1 and 2. Adding fish screens on a new forebay intake under Alternatives 1B and 1C and Alternatives 2 and 3 would decrease predation losses of all Delta species because fish would be salvaged prior to entry into the forebay. An unknown level of predation associated with movement of fish toward the Clifton Court intake would continue to occur in the adjacent Delta channels.

Under all alternatives, creating new aquatic habitat by inundating Delta islands may increase the abundance of carp, inland silversides, or other non-native species. Non-native species may compete with or prey on native or economically important species. The Ecosystem Restoration Program includes actions that may reduce the influx of non-native aquatic species from ship ballast water and directly control populations of non-native species. The actions may decrease the adverse impacts associated with establishment of non-native species in the Delta, including increased competition, predation, and disease. Other Ecosystem Restoration Program actions that may reduce predation and competition in the Delta include improved hatchery practices, reduced predator habitat, improved fish passage at barriers, and restored habitat diversity and complexity for native species.

Artificial Production

Under all alternatives, targets for artificial production in the Ecosystem Restoration Program include managing fish propagation programs consistent with rehabilitation of naturally producing fish populations, conserving ecological and genetic values, achieving recovery of special-status species, and maintaining healthy populations of other species. In general, these actions would result in beneficial impacts on striped bass, steelhead, and chinook salmon.

Harvest

Under all alternatives, actions in the Ecosystem Restoration Program designed to reduce illegal harvest and improve harvest management for anadromous fish would result in increased survival of adult fish and reduce impacts on self-sustaining natural populations. Such actions include improving harvest regulations, providing additional law enforcement, and developing a strong public education program. Species most likely to benefit from such actions include striped bass, sturgeon, chinook salmon, and steelhead.

ALTERNATIVE 2

Alternative 2 consists of four Configurations with through-Delta conveyance (2A, 2B, 2D, and 2E) as a unique and unifying element (Table 10). Alternatives 2A, 2B, and 2D would include a screened flow diversion at Hood as part of the through-Delta conveyance. Alternative 2E would include a new unscreened flow diversion point off the Sacramento River near the DCC.

As under Alternative 1C, Alternative 2 includes new SWP and CVP fish screens and a new Clifton Court Forebay intake, an intertie between the CVP Tracy pumping facility and

Clifton Court, full SWP pumping capacity, and an operable head-of-Old-River barrier (Table 10). Alternatives 2A and 2B include the south-Delta barriers. Alternatives 2B and 2E include substantial new storage components; and Alternative 2E includes several thousand acres of additional flooded, tidally connected Delta islands.

Although impacts of implementing Alternative 2 were identified under Alternative 1, through-Delta facilities, reconstruction of aquatic habitat, and operations changes would cause additional impacts specific to Alternative 2.

Ecosystem-Level Impacts

Flow

Operations rules and demands would be similar under Alternative 2 and the No Action Alternative. The major change in flow patterns under Alternative 2 would be attributable to diversion of additional Sacramento River flow into Mokelumne River channels and across the central and south Delta toward the SWP and CVP export facilities.

Under Alternative 2, average annual exports would increase by from 270 to 624 TAF (from 4 to 10%) relative to the No Action Alternative. South-Delta channel modifications would relax current regulatory constraints and allow the export pumps to operate to their physical capacity. Under Alternatives 2B, 2D, and 2E, new upstream and in-Delta storage capacity would augment water available for export. Exports would increase primarily from November through January and in April and May (Table 11). Adverse effects of exports under the No Action Alternative would continue, and additional exports would increase entrainment loss of Delta productivity and nutrients. Although exports would be reduced during February and March under Alternative 2A, beneficial impacts would be minimal considering the season and increased exports during other months.

Increased exports under Alternative 2 would increase the frequency of low outflows from November through January. Reduced outflow would shift X2 and the distribution of associated organisms upstream. Adverse impacts could include reduced habitat and increased entrainment of organisms in Delta diversions, but the overall effect on the ecosystem would be minor relative to other impacts related to increased exports and changes in Delta structure.

Under Alternative 2, net flow of Old and Middle rivers would continue to be toward the SWP and CVP export facilities, and flow conditions would be opposite that of the natural condition, which is net flow toward Suisun Bay. Increased exports under Alternative 2, especially under Alternatives 2B and 2E, would increase the movement of Sacramento River flow across the Delta and down Old and Middle rivers toward the export facilities. More importantly, however, new and modified channels would substantially affect Delta flow conditions in Mokelumne River channels. New flow diversion points off the Sacramento River would increase cross-Delta flow (flow from the Sacramento River that moves into the north and south Mokelumne River channels and Georgiana Slough) and QWEST flow toward Suisun Bay (increased frequency of flow above the high range) (Tables 17 and 18). A screened Hood intake would be constructed under Alternatives 2A, 2B, and 2D. Under Alternative 2E, an unscreened Tyler Island intake would be constructed near the DCC and Georgiana Slough.

Increased cross-Delta flow would reduce residence of water in the east, central, and south Delta, reducing productivity and increasing entrainment of organisms and nutrients. The change in residence time is illustrated by the fate of water injected at Snodgrass Slough, Prisoners Point, and Old River near Rock Slough (Table 15). Beneficial impacts of increased cross-Delta flow and subsequent increase in QWEST (Table 18) may include improved survival of organisms moving from the lower San Joaquin River and toward Suisun Bay. Movement of mass injected at Jersey Point illustrates increased movement past Chipps Island (Table 19).

Both the Hood and Tyler Island intakes would increase cross-Delta flow and reduce Sacramento River flow (Tables 17 and 20). Both intake points may include operable flow control structures. When the structures are closed, cross-Delta flow conditions would be the same as those under the No Action Alternative. At low Sacramento River flow, the Hood intake, which includes pumping facilities, could divert nearly all the Sacramento River flow to cross-Delta flow. The Tyler Island intake has a greater capacity than the Hood intake and, under high Sacramento River flow, could divert substantially more Sacramento River flow to cross-Delta flow (Figure 3).

Increased cross-Delta flow, regardless of the diversion point, increases the Delta residence time of Sacramento River water (Table 15). Although additional Sacramento River water contributes to cross-Delta flow and QWEST, the proportion of Sacramento and San Joaquin River water entrained in Delta island diversions and exports would be nearly the same as under the No Action Alternative (illustrated by simulated entrainment for injection locations at Freeport and Vernalis in Table 14). The slightly lower simulated entrainment of Sacramento River water (illustrated by injection of mass at Freeport for October 1989) is attributable to increased residence time (Table 15).

From August through October, when Delta outflow is relatively low and diversion of cross-Delta flow substantially reduces net Sacramento River flow downstream of Georgiana Slough, the resulting conditions may shift X2 farther into the Delta (Table 21). The Hood (Alternatives 2A, 2B, and 2D) and Tyler Island (Alternative 2E) intakes increase the potential to shift X2 upstream by reducing net Sacramento River flow (Table 20). The Hood diversion, because it incorporates a pumping facility, potentially diverts more of the Sacramento River flow during low-flow periods than would the Tyler Island diversion. Location of X2 farther upstream in the Delta potentially exposes organisms associated with X2 to entrainment in Delta diversions. The impacts of reduced Sacramento River flow also would occur under Alternative 3 (Table 20).

Sediment and Nutrient Input and Movement

Sediment and nutrient input and movement impacts under Alternative 2 would be similar to those described under Alternative 1. Additional structural changes to the Delta, including through-Delta facilities and additional Delta island flooding (Alternative 2E), would affect sediment movement. The through-Delta facilities would increase sediment movement from the Sacramento River into Mokelumne River channels. Flooded Delta islands may capture sediment and reduce supply to downstream areas. Reduced sediment supply to the Sacramento River channel may reduce deposition and maintenance of existing shallow edge areas and further reduce structural diversity along the Sacramento River channel. Increased sediment input to Mokelumne River channels may fill existing shallow-water areas and reduce aquatic habitat availability. Capture of sediments in newly flooded islands may result in erosion of remaining nearby channel islands and shallow edge areas. Site-specific studies will be needed to determine erosion and depositional effects of flow and structural changes.

Sediments held in suspension as a result of high-flow velocities in the Sacramento River will settle out as river velocity slows. Channel velocities will decrease downstream of intake structures that draw off a large fraction of the river flow. Movement of additional flow through the Hood diversion (Alternatives 2A, 2B, and 2D) and Tyler Island diversion (Alternative 2E) would reduce net flow velocity in the Sacramento River. Sediment may temporarily accumulate in and along the Sacramento River channel.

High velocities that occur during high-flow periods and velocity attributable to tidal flow would continue to occur and would mobilize sediments deposited during periods of reduced net flow.

Productivity

As described under "Flow," adverse impacts may result from reduced residence time and potentially reduced productivity in the east and central Delta.

The additional reconstruction of aquatic communities for Alternative 2E would substantially add to the increased productivity identified for Alternative 1 that would occur under the Ecosystem Restoration Program. Increased production would result from increased area available to support aquatic plants, including algae and vascular plants, and increased density of plants in restored habitats. Additional benefits to aquatic productivity under this alternative may result from water quality improvements in the Delta.

Structural Characteristics

Under Alternative 2E, several thousand additional acres of aquatic areas in the Delta would be reconstructed, substantially adding to the amount of aquatic communities reconstructed under the Ecosystem Restoration Program. The addition of the Hood diversion (Alternatives 2A, 2B, and 2D) would substantially alter the structure of east-Delta channels, especially Snodgrass Slough. The Hood diversion would increase flow in Snodgrass Slough and reduce residence time relative to existing conditions. The structural change would affect sediment and nutrient movement, productivity, and other ecosystem processes.

Species-Level Impacts

Habitat

In addition to habitat restoration in the Ecosystem Restoration Program, an additional 10,000 to 20,000 acres of aquatic area would be created under Alternatives 2D, 2E, and 3H. The reconstructed areas may provide spawning and rearing habitat for delta smelt, splittail, and other Delta species. Juvenile chinook salmon, steelhead, and striped bass also may benefit from additional rearing habitat. Beneficial impacts are contingent, however, on the availability of suitable spawning and rearing conditions. Specific species needs should be incorporated into reconstruction designs and monitoring and mitigation programs implemented to ensure suitability of reconstructed habitat.

Under Alternatives 2A, 2B, and 2D, existing unique, high-quality shallow-water, riparian, and SRA habitats in the Snodgrass Slough natural area and adjacent areas would be eliminated or modified by construction and operation of the through-Delta conveyance. Construction of setback levees and erosion of the channel islands also may destroy existing spawning and rearing habitat along Mokelumne River channels. The loss or change in habitat under Alternatives 2A, 2B, and 2D could adversely affect spawning and rearing success of Delta species. Alternative 2E would not include modifications to the Snodgrass Slough natural area and, with reconstruction of habitat that meets species needs, could benefit spawning and rearing success of Delta species.

Increased Delta exports would increase loss of Delta productivity and further degrade rearing-habitat conditions relative to the No Action Alternative, particularly in the central and south Delta. Larvae and juveniles of species that feed on planktonic organisms, including striped bass and delta smelt, most likely would be most affected.

Under Alternative 2 and 3, X2 would shift farther upstream in the Delta during summer and fall in response to reduced Sacramento River flow downstream of the new Hood and Tyler Island through-Delta intakes (Tables 20 and 21) and to reduced Delta outflow during November and December. Relative to the No Action Alternative, location of X2 farther upstream potentially would reduce habitat quantity and quality for organisms associated with X2—for example, striped bass and delta smelt. The upstream shift in X2 would contribute to ongoing adverse impacts occurring under the No Action Alternative.

Entrainment

Impacts of Ecosystem Restoration Program actions addressing fish screens and predation associated with diversion facilities, impacts of the intertie between the SWP and CVP

Alternative	Variability of Net Cross-Delta Flow (%)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1A												
Frequency below low range[a]	19	6	13	13	0	13	0	0	19	13	19	0
Frequency above high range[b]	13	13	13	19	25	19	13	13	19	19	19	13
1C												
Frequency below low range[a]	19	6	13	13	0	13	0	6	19	13	19	0
Frequency above high range[b]	13	13	13	19	25	19	13	13	19	19	19	13
2B												
Frequency below low range[a]	6	0	0	0	0	0	0	0	13	13	13	0
Frequency above high range[b]	75	81	81	88	75	81	63	81	81	81	69	69
2D												
Frequency below low range[a]	6	0	0	0	0	0	0	0	13	13	6	0
Frequency above high range[b]	75	81	81	88	75	81	63	75	75	81	69	69
2E												
Frequency below low range[a]	0	0	0	0	0	0	0	0	0	6	0	0
Frequency above high range[b]	81	75	81	88	81	94	94	100	94	81	75	69
3E												
Frequency below low range[a]	100	88	81	69	44	31	50	75	94	100	100	100
Frequency above high range[b]	0	6	13	13	19	19	13	6	0	0	0	0

NOTES:

[a] Low range is the average flow for Alternative 1A conditions minus 1 standard deviation or the minimum flow, whichever is largest.

[b] High range is the average flow for Alternative 1A conditions plus 1 standard deviation or the maximum flow, whichever is smallest.

SOURCES:
DWRDSM studies, CALFED 1997b.

Table 17. Percent Variability of Net Cross-Delta Flow by Alternative

C-008134

Alternative	Variability of QWEST (%)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1A												
Frequency below low range[a]	6	13	0	6	0	0	0	0	0	19	19	25
Frequency above high range[b]	13	13	13	19	19	13	13	13	6	6	19	25
1C												
Frequency below low range[a]	6	13	0	6	0	0	6	6	0	19	19	25
Frequency above high range[b]	13	13	13	19	19	13	13	13	6	6	19	25
2B												
Frequency below low range[a]	0	0	0	0	0	0	0	0	0	0	0	0
Frequency above high range[b]	75	13	13	25	25	19	19	31	6	31	88	100
2D												
Frequency below low range[a]	0	0	0	0	0	0	0	0	0	0	0	0
Frequency above high range[b]	75	13	13	25	25	19	19	31	6	25	81	100
2E												
Frequency below low range[a]	0	0	0	0	0	0	0	0	0	0	0	0
Frequency above high range[b]	44	25	19	31	31	31	19	31	6	50	88	100
3E												
Frequency below low range[a]	0	0	0	0	0	0	0	0	0	0	0	0
Frequency above high range[b]	56	25	19	25	25	19	19	31	13	44	100	100

NOTES:

[a] Low range is the average flow for Alternative 1A conditions minus 1 standard deviation or the minimum flow, whichever is largest.

[b] High range is the average flow for Alternative 1A conditions plus 1 standard deviation or the maximum flow, whichever is smallest.

SOURCES:
DWRDSM studies, CALFED 1997b.

Table 18. Percent Variability of QWEST by Alternative

facilities, and impacts of an enlarged Clifton Court intake are described under Alternative 1. Under Alternative 2, ongoing entrainment losses that are not reduced by fish screens would continue. Exports would increase primarily from November through January and in April and May (Table 11), affecting egg and larval striped bass, delta smelt, longfin smelt, chinook salmon, and splittail. Planktonic organisms, such as mysids, rotifers, and fish eggs and larvae, would be most affected.

Movement

Effects of the south-Delta barriers and head-of-Old-River barrier on movement were discussed under Alternative 1. Increased exports, as discussed for Alternative 1C, would further increase flow in Old and Middle rivers toward the SWP and CVP export facilities. The increased net flow could adversely affect movement of juvenile chinook salmon, delta smelt, longfin smelt, striped bass, and other Delta species toward Suisun Bay. Under the

Injection Location	Movement Past Chipps Island of Mass Introduced at Discrete Delta Locations (%)					
	1A	1C	2B	2D	2E	3E
Vernalis						
February 1979	4	4	7	9	11	79
April 1981	0	0	1	2	3	8
October 1989	0	0	0	0	0	0
July 1991	0	0	0	0	0	0
Freeport						
February 1979	98	98	76	76	96	63
April 1981	69	69	55	54	55	41
October 1989	19	20	12	13	8	6
July 1991	10	10	9	8	2	6
Rio Vista						
February 1979	100	100	100	100	100	100
April 1981	87	86	94	93	94	96
October 1989	43	43	35	36	37	38
July 1991	35	35	32	31	22	31
Jersey Point						
February 1979	98	98	100	99	100	100
April 1981	62	60	88	86	92	93
October 1989	21	21	32	29	27	31
July 1991	27	27	28	28	32	30
Prisoners Point						
February 1979	74	75	84	81	89	100
April 1981	6	8	23	23	30	63
October 1989	0	1	1	1	1	2
July 1991	1	1	2	2	2	1
Old River at Rock Slough						
February 1979	9	9	11			78
April 1981	3	2	4			0
October 1989	0	0	1			1
July 1991	1	1	1			1
Snodgrass Slough						
February 1979	89	89	98			99
April 1981	2	2	53			3
October 1989	2	2	6			0
July 1991	4	4	5			3

SOURCES:

DWRDSM studies, CALFED 1997b.

Table 19. Movement past Chipps Island of Mass Introduced at Discrete Delta Locations by Alternative

Alternative	Variability of Sacramento River Net Flow (%)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1A												
Frequency below low range[a]	0	0	0	6	0	0	0	0	0	19	19	0
Frequency above high range[b]	13	25	19	19	19	13	13	13	6	19	13	13
1C												
Frequency below low range[a]	0	6	6	6	6	6	6	6	0	19	19	13
Frequency above high range[b]	13	19	19	19	19	13	13	13	6	13	13	13
2B												
Frequency below low range[a]	44	63	50	19	44	13	31	63	6	44	56	88
Frequency above high range[b]	0	6	13	19	19	13	13	6	6	0	0	6
2D												
Frequency below low range[a]	44	63	44	19	44	13	25	56	6	44	50	88
Frequency above high range[b]	0	6	13	19	19	13	13	6	6	0	0	6
2E												
Frequency below low range[a]	50	56	44	19	50	19	63	75	56	69	69	69
Frequency above high range[b]	0	6	13	6	13	13	13	6	6	0	0	0
3E												
Frequency below low range[a]	56	69	63	19	38	6	31	63	6	94	94	88
Frequency above high range[b]	0	6	13	19	19	13	13	6	6	0	0	6

NOTES:

[a] Low range is the average flow for Alternative 1A conditions minus 1 standard deviation or the minimum flow, whichever is largest.

[b] High range is the average flow for Alternative 1A conditions plus 1 standard deviation or the maximum flow, whichever is smallest.

SOURCES:
DWRDSM studies, CALFED 1997b.

Table 20. Percent Variability of Sacramento River Net Flow (Net Flow at Rio Vista) by Alternative

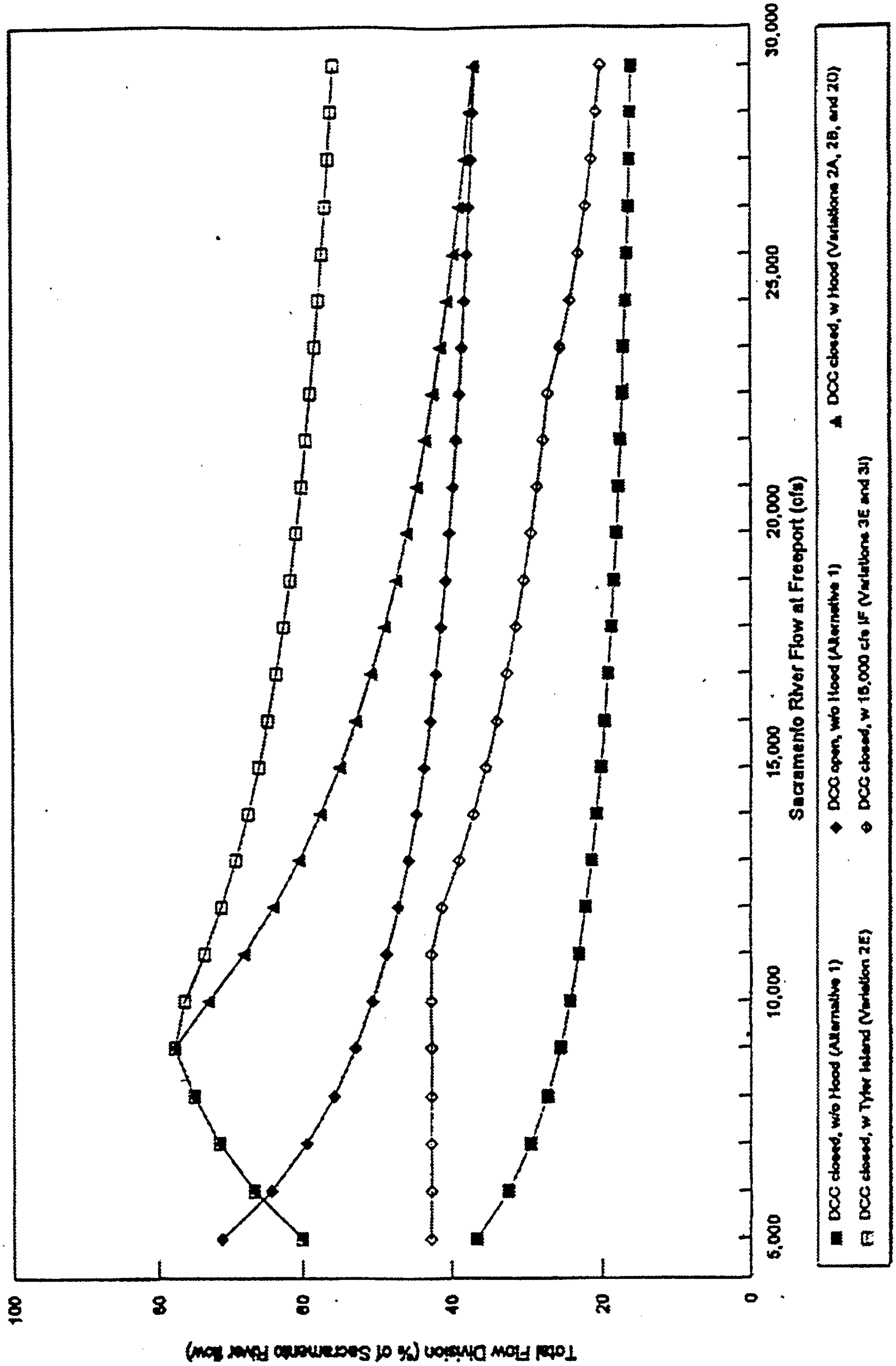

Figure 3. Relationship Between Sacramento River Flow Volume and the Ratio of Cross-Delta Flow to Sacramento River Flow (Total Flow Division)

Alternative	Variability in X2 Attributable to Reduced Sacramento River Net Outflow (%)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1A												
Frequency below low range[a]	19	25	19	0	0	0	0	0	0	6	6	13
Frequency above high range[b]	19	63	63	25	38	38	63	81	81	56	44	50
1C												
Frequency below low range[a]	19	25	19	0	0	0	0	0	0	6	6	13
Frequency above high range[b]	19	63	63	25	38	38	63	81	81	56	44	50
2B												
Frequency below low range[a]	19	25	19	0	0	0	0	0	0	6	6	13
Frequency above high range[b]	44	69	63	25	38	38	63	81	81	56	56	69
2D												
Frequency below low range[a]	19	25	19	0	0	0	0	0	0	6	6	13
Frequency above high range[b]	38	63	63	25	25	38	56	81	69	56	56	69
2E												
Frequency below low range[a]	19	25	19	0	0	0	0	0	0	6	6	13
Frequency above high range[b]	25	63	63	25	19	38	50	81	69	56	56	63
3E												
Frequency below low range[a]	19	25	19	0	0	0	0	0	0	6	6	13
Frequency above high range[b]	50	69	63	25	38	38	56	81	69	56	56	69

NOTES:

[a] Low range is the average flow for Alternative 1A conditions minus 1 standard deviation or the minimum flow, whichever is largest.

[b] High range is the average flow for Alternative 1A conditions plus 1 standard deviation or the maximum flow, whichever is smallest.

SOURCES:
DWRDSM studies, CALFED 1997b.

Table 21. Percent Variability in X2 Attributable to Reduced Sacramento River Net Outflow by Alternative

existing Delta configuration, impacts of increased southerly flow in Old and Middle rivers that are attributable to increased SWP and CVP exports would be unavoidable.

The Hood and Tyler Island intakes also would increase movement of striped bass eggs and larvae and splittail larvae with cross-Delta flow. The proportion of the populations affected could be substantial, depending on the volume of the diversion during striped bass spawning (May and June) and splittail downstream migration (March to June, especially during drier years). American shad also may be affected, with larvae moving downstream from May through July and juveniles passing the intakes primarily during fall. Increased movement with cross-Delta flow may result in adverse impacts, such as increased entrainment resulting from movement with net flow across the central Delta and down Old and Middle rivers toward the export facilities.

Increased cross-Delta flow and the resulting increased flow in the lower San Joaquin River and toward Suisun Bay (QWEST in Table 18) may reduce entrainment of species with planktonic life stages and species dependent on flow cues for movement to downstream habitat. Species likely to benefit include juvenile chinook salmon and larval and juvenile delta smelt and striped bass in the lower San Joaquin River.

Under the No Action Alternative, chinook salmon from the Sacramento River are drawn through the DCC and Georgiana Slough and into the Mokelumne River channels and central-Delta, where survival during downstream migration is lower than survival of fish continuing down the Sacramento River because of higher entrainment and other factors. The through-Delta facilities would increase flow to Mokelumne River channels. Although fish screens would prevent or reduce movement of juvenile chinook salmon, steelhead, and other screenable species with flow into the through-Delta facility at Hood (under Alternatives 2A, 2B, and 2D), fish remaining in the river would be exposed to the flow diversion into an unscreened Georgiana Slough. The increased proportion of remaining Sacramento River flow diverted into Georgiana Slough would increase movement of downstream-migrating species into Georgiana Slough, including juvenile chinook salmon and steelhead, egg and larval striped bass, and larval and juvenile American shad. Based on existing information, survival of salmon that remain in the Sacramento River is greater than survival of salmon drawn into Georgiana Slough. The isolated facility could significantly affect survival of downstream migrant chinook salmon and potentially other species of outmigrants.

Conditions would be improved relative to the No Action Alternative when the DCC is open, which is during September and October and part of November to January and June. The proportion of flow drawn off the Sacramento River and into Georgiana Slough under Alternatives 2A, 2B, and 2D would be less than the proportion under existing conditions (Figure 3). Benefits may accrue to outmigrating American shad juveniles; however, migration of other species generally occurs when the DCC is closed, and operation of the isolated facility would benefit only part of the migrant population. Losses associated with the fish screen facility on the through-Delta facility would further diminish any benefits related to flow division at Georgiana Slough and contribute to the potentially significant impact identified above.

Under Alternative 2E, the new unscreened Tyler Island intake would increase movement of Sacramento River flow and migrant juvenile chinook salmon to Mokelumne River channels. Alternative 2E has a potentially greater adverse effect on outmigrants in the Sacramento River than other Configurations of Alternative 2; however, increased cross-Delta flow may improve conditions in Mokelumne River channels and increase survival relative to historical levels. Conversely, reduced flow in the Sacramento River below the through-Delta intakes may degrade conditions affecting movement and reduce survival of migrants along the lower Sacramento River route. The impact on juvenile chinook salmon is uncertain and will require implementation of appropriate studies to determine the best operation of a through-Delta facility.

Reduced net flow in the Sacramento River channel could adversely increase settling of striped bass eggs and larvae through increased areas of zero flow during shift in the tidal cycle. Settling of striped bass eggs and larvae could reduce survival and adversely affect striped bass abundance.

Adverse impacts on movement of juvenile chinook salmon, striped bass, and other Delta species may be avoided and minimized through monitoring programs that determine species effects and implementation of management strategies to provide suitable habitat conditions. Depending on species needs, the Hood and Tyler Island intake structures may be operated to increase cross-Delta flow or to maintain flow in the Sacramento River.

The screened through-Delta facility on the Sacramento River in Alternatives 2A, 2B, and 2D would attract upstream migrating adult anadromous fish into Mokelumne River channels. Affected species include chinook salmon, steelhead, striped bass, American shad, and sturgeon. The fish screen would prevent movement from the Mokelumne River channels into the Sacramento River and could increase losses from disorientation and migration delay. Additionally, adult chinook salmon returning to the Sacramento River basin may stray into the Mokelumne River. The loss of adult fish would be a potentially significant adverse impact. Implementing monitoring and adaptive management strategies discussed above could mitigate the impact. Mitigation could also include constructing active and passive fish transport facilities or operating the Hood intake structure to avoid increased cross-Delta flow and attraction of adult fish.

ALTERNATIVE 3

Alternative 3 consists of five Configurations with an isolated facility as a unique and unifying element (Table 10). The isolated facilities vary in capacity from 5,000 cfs (Alternatives 3A, 3B, and 3H) to 15,000 cfs (Alternatives 3E and 3I). All Configurations include a screened isolated facility intake at Hood. Alternative 3H includes a new unscreened flow diversion point off the Sacramento River near the DCC and several thousand acres of additional flooded, tidally connected Delta aquatic habitat, similar to Alternative 2E. Alternative 3I includes three new intakes off the San Joaquin River in the central and south-Delta.

As under Alternatives 1 and 2, Alternative 3 includes new SWP and CVP fish screens and a new Clifton Court Forebay intake, an intertie between the CVP Tracy pumping facility and Clifton Court, full SWP pumping capacity, and an operable head-of-Old-River barrier (Table 10). Alternatives 3A and 3B include south-Delta barriers. Alternatives 3B, 3E, 3H, and 3I include substantial new storage components.

Although many impacts attributable to implementation of Alternative 3 were identified under Alternatives 1 and 2, the isolated facility and operations changes cause additional impacts specific to Alternative 3.

An isolated facility and south Delta channel modifications would allow the use of full physical SWP pump capacity. In addition, an isolated facility may allow relaxation of the export:inflow criteria. Relative to the No Action Alternative, new storage, especially offstream storage south of the Delta, full use of the SWP pump capacity, and relaxation of export:inflow criteria would increase the potential for water transfers. Depending on the source of water transfers, Delta exports may increase, Delta outflow may be reduced, and timing of Delta inflow may be altered. Transfer of stored water in reservoirs has the greatest potential for significant adverse impacts, potentially contributing to adverse impacts that result from existing reservoir operations.

Ecosystem-Level Impacts

Flow

Operations rules and demands would be the same under Alternative 3 and the No Action Alternative; however, export through the isolated facility with an intake on the Sacramento River would substantially alter flow patterns throughout the Delta. The isolated facility diversion would reduce exports from the south Delta and increase the occurrence of more natural flow patterns in the east, central, and south Delta, as well as in the lower San Joaquin River.

Export off the Sacramento River at Hood and extended closure of the DCC from September though June also would reduce cross-Delta flow, which is flow from the Sacramento River that moves into the north and south Mokelumne River channels and Georgiana Slough. Beneficial impacts may include a return to a more natural flow condition in Mokelumne River channels that primarily depend on tidal flow and inflow from the Mokelumne River and increased productivity because of increased residence time (as indicated by residence of mass for the Snodgrass Slough injection in Table 15).

Under Alternative 3H, however, cross-Delta flow could increase because of diversion through the Tyler Island intake. Beneficial impacts of increased cross-Delta flow may include flow conditions that improve survival of organisms moving toward Suisun Bay (as indicated by movement past Chipps Island in Table 19). Adverse impacts may include reduced productivity attributable to reduced residence time in the east and central Delta (as indicated by injection of mass at Snodgrass Slough and Prisoners Point for Alternative 2E in Table 15).

Although average annual export under Configuration 3A would be 6,531 TAF compared to 6,290 TAF under the No Action Alternative, average annual exports from the south Delta would be reduced to 3,232 TAF (Table 22). A similar reduction in south-Delta exports would occur under Alternatives 3B and 3H (3,533 TAF annual average export). Average annual south-Delta exports under Alternatives 3E and 3I would be 847 TAF, substantially less than under Alternatives 3A, 3B, and 3H. The lower south-Delta exports are attributable to the 15,000-cfs capacity isolated facility under Alternatives 3E and 3I compared to the 5,000-cfs capacity under Alternatives 3A, 3B, and 3H.

The substantial reduction in exports from the south Delta under Alternative 3 would result in beneficial impacts through reduced entrainment loss of nutrients and organisms. Benefits would be greatest for the central and south Delta (as indicated by entrainment of mass for the Prisoners Point and Old River injections in Table 13), and could be substantial for the east and west Delta under some conditions (as indicated by entrainment of mass for Snodgrass Slough, Jersey Point, and Rio Vista injections in Table 13).

Under Alternatives 3A, 3B, and 3H, net flow of Old and Middle rivers continues to be toward the SWP and CVP export facilities. Although flow direction is opposite that of the natural condition much of the time, the net reverse flow volume would be reduced by about 50%, based on the reduction in export from the south-Delta facilities (Table 22). Under Alternatives 3E and 3I, net flow of Old and Middle rivers generally would be toward Suisun Bay, more closely approximating the natural flow condition (as indicated by simulated Alternative 3E in Table 16).

Similarly, QWEST (flow in the lower San Joaquin River) would increase toward Suisun Bay (Table 18). Under Alternatives 3A and 3B, negative QWEST (flow toward the central Delta from the lower San Joaquin River) would continue to occur. Although the existing flow direction is opposite that of the natural condition during some months, the net reverse flow volume would be reduced by about 50%, based on the reduction in export from the south-Delta facilities shown in Table 22. As indicated by simulated Configuration 3E in Table 18, QWEST under Alternatives 3E and 3I generally would be toward Suisun Bay, more closely approximating the natural flow condition. Additionally, the Tyler Island intake under Alternative 3H may substantially increase cross-Delta flow and contribute to an even greater increase in QWEST than indicated in Table 18. Beneficial impacts may include improved transport of organisms toward Suisun Bay.

The isolated facility would allow the export pumps to operate to their physical capacity. Under Alternatives 3B, 3H, 3E, and 3I, new upstream and in-Delta storage capacity would augment water available for export. Average annual exports would increase by approximately 240 to 560 TAF (from 4 to 9%) relative to the No Action Alternative, primarily from November through December and in April and May (Table 11). Partially attributable to increased export, the frequency of low outflows would increase during January under Alternatives 3A, 3B, and 3H. Reduced outflow would shift X2 upstream, reducing habitat for some Delta species and increasing exposure to Delta diversions for species redistributed upstream. Under Alternatives 3E and 3I, the frequency of low outflows from October through December would decrease, indicating increased outflow. Increased outflow would shift X2 and the distribution of associated organisms downstream, potentially increasing habitat and reducing entrainment of organisms in Delta diversions. The overall effect of change in outflow would be minor relative to other impacts related to increased exports and changes in Delta structure.

Alternative 3I includes three new intake locations along the San Joaquin River and in the central Delta. These intakes, together with the existing SWP and CVP intakes, would allow water to be diverted into isolated facilities. Operation of the new intakes and subsequent effects on flow, in conjunction with the isolated facility intake at Hood on the Sacramento River and with a new Clifton Court Forebay intake, cannot be determined with available information.

Sediment and Nutrient Input and Movement

Additional structural changes to the Delta, including through-Delta facilities, additional Delta island flooding (Alternative 3H), and the isolated facility, would affect sediment movement. The effects would be similar to those described for Alternatives 1 and 2.

Productivity

As discussed above under "Flow," beneficial impacts of increased residence time in Mokelumne River channels and in the east, central, and south Delta may include increased productivity. Increased residence time is indicated by residence of mass injected at Prisoners Point, Snodgrass Slough, and Old River near Rock Slough (Table 15). Increased residence of mass injected at Vernalis (Table 15) indicates a greater percentage of San Joaquin River flow, higher in nutrient concentrations than Sacramento River flow, also would increase productivity. San Joaquin River residence time would increase most during periods of low Delta agricultural diversion, from November to March.

Relocation of SWP and CVP Delta exports to the Sacramento River, outside the area of high Delta productivity in the central and south Delta, would reduce the entrainment of nutrients and foodweb organisms. Alternatives 3E and 3I would provide greater opportunity to reduce loss of organisms because of the larger size of the isolated facility and substantially reduced south-Delta diversion (Table 22).

Therefore, aquatic productivity, in general, is expected to be higher under this alternative because of the increased water residence time in the Delta, increased proportion of San Joaquin River flow in the Delta, and reduced entrainment of nutrients and foodweb organisms at the export facilities.

Structural Characteristics

As identified under "Flow," the relocation of SWP and CVP exports to an isolated facility is the major structural change unique to Alternative 3. Several thousand additional acres of aquatic areas in the Delta would be restored under Alternative 3H, substantially adding to restoration benefits realized under the Ecosystem Restoration Program.

Species-Level Impacts

Habitat

In addition to habitat restoration in the Ecosystem Restoration Program, an additional 10,000 to 20,000 acres of aquatic area would be created under Alternative 3H. The reconstructed areas may provide spawning and rearing habitat for delta smelt, splittail, and other Delta species. Juvenile chinook salmon, steelhead, and striped bass also may benefit from additional rearing habitat. Beneficial impacts, however, are contingent on the availability of suitable spawning and rearing conditions. Specific species needs should be incorporated into reconstruction designs and monitoring and mitigation programs implemented to ensure suitability of reconstructed habitat.

Increased Delta exports would increase loss of Delta productivity; however, the diversion point for SWP and CVP exports would be shifted to the Sacramento River, outside the primary spawning and rearing habitat for most Delta species. Rearing-habitat conditions, relative to the No Action Alternative, would improve in the east, central, and south Delta. Larvae and juveniles of species that feed on planktonic organisms, including striped bass and delta smelt, would benefit most.

Entrainment

Alternative 3 would result in a major relocation of the diversion point for SWP and CVP exports and would substantially reduce entrainment of Delta species. Fish species that spawn and rear in the central and south Delta, including delta

Month	No Action	Alternatives 3A	3B and 3H	3E and 3I
October	556 (100)	305 (49)	304 (49)	82 (20)
November	546 (100)	316 (48)	313 (47)	75 (16)
December	636 (100)	403 (53)	395 (53)	75 (12)
January	678 (100)	398 (53)	445 (56)	73 (11)
February	539 (100)	212 (42)	293 (50)	67 (15)
March	557 (100)	216 (40)	291 (46)	79 (15)
April	293 (100)	67 (15)	77 (18)	21 (6)
May	309 (100)	77 (19)	98 (23)	43 (13)
June	460 (100)	193 (35)	207 (36)	49 (13)
July	605 (100)	460 (61)	460 (63)	115 (26)
August	580 (100)	304 (53)	376 (57)	89 (23)
September	532 (100)	281 (47)	274 (46)	81 (17)
Annual total	**6,290 (100)**	**3,232 (49)**	**3,533 (52)**	**847 (12)**

NOTE:

First amount represents thousand acre-feet. Second amount (in parentheses) indicates percent.

SOURCES:
DWRDSM studies, CALFED 1997b.

Table 22. Average Monthly Export from the South-Delta SWP and CVP Pumping Facilities in Thousand Acre-Feet and Percentage of Total Export for the 1922 to 1993 DWRSIM Simulation

smelt, striped bass, and splittail, would benefit. The 15,000-cfs isolated facility (Alternatives 3E and 3I) would provide greater opportunities to reduce entrainment impacts on species in the east, central, and south Delta compared to the 5,000-cfs isolated facility.

The Sacramento River diversion point may cause significant adverse impacts on species entering the Delta with Sacramento River flow, including juvenile chinook salmon, striped bass, American shad, and splittail. Screening efficiency would need to be determined on a site-specific basis and screens on the larger isolated facility (Alternatives 3E and 3I) are potentially less efficient than screens on a smaller facility. Because egg and larval life stages cannot be effectively screened, the isolated facility intake would increase entrainment loss of striped bass eggs and larvae and splittail larvae transported with Sacramento River flow. The proportion of the populations affected could be substantial, depending on the volume of the diversion during striped bass spawning (May and June) and splittail downstream migration (March to June, especially during drier years). American shad also may be affected, with larvae moving downstream from May through July and juveniles passing the intakes primarily during fall. Increased entrainment would cause potentially significant adverse impacts; however, operations that avoid diversion during the presence of vulnerable life stages could reduce entrainment loss.

In Alternative 3I, the three unscreened intakes in the south Delta could increase entrainment loss of fish from the lower San Joaquin River and the central Delta compared with the No Action Alternative. Although the multiple intakes enable flexible operations and the opportunity to avoid entrainment in any one intake, reduced entrainment loss depends on detection prior to entrainment and movement of fish out of the influence of the central- and south-Delta diversions. The unscreened intakes would be located closer to the center of distribution of many Delta species, including larval and early juvenile striped bass and delta smelt. The diversion points would not be screened and the isolated channels would most likely increase predation-related mortality to an extent potentially greater than predation losses that occur in the existing Clifton Court Forebay. The 15,000-cfs isolated facility included in Alternative 3I provides the opportunity to avoid entrainment-related impacts on species in the central and south Delta.

Movement

The isolated facility intake constructed under Alternative 3 would reduce cross-Delta flow (Table 17), reduce Sacramento River net flow, and increase the proportion of Sacramento River flow diverted relative to that diverted under the No Action Alternative when the DCC is closed (Figure 3). Although fish screens would reduce entrainment of juvenile chinook salmon, steelhead, and other screenable species into the isolated facility, fish remaining in the river would be exposed to the flow division into Georgiana Slough. The increased proportion of remaining Sacramento River flow diverted into Georgiana Slough would increase movement of downstream migrants into Georgiana Slough, including juvenile chinook salmon and steelhead, egg and larval striped bass, and larval and juvenile American shad. Based on existing information relative to survival of juvenile chinook salmon, survival of salmon that remain in the Sacramento River is greater than survival of salmon drawn into Georgiana Slough. The isolated facility could significantly affect the survival of downstream migrant chinook salmon and potentially other species of outmigrants.

Conditions would be improved relative to the proportion of flow diverted when the DCC is open under the No Action Alternative and closed under Alternative 3 (during September and October, and part of November to January and June). The proportion of flow drawn off the Sacramento River and into Georgiana Slough under Alternative 3 would be less than the proportion under existing conditions (Figure 3). Benefits may accrue to outmigrating American shad juveniles; however, migration of other species generally occurs when the DCC is closed and operation of the isolated facility would benefit only part of the migrant population. Losses associated with the screened isolated facility diversion would further diminish any benefits related to flow division.

In Alternative 3H, the new unscreened Tyler Island intake would increase movement of Sacramento River flow and migrant juvenile chinook salmon to Mokelumne River channels. Alternative 3H has a potentially greater adverse effect on outmigrants in the Sacramento River than other Configurations of Alternative 3; however, increased cross-Delta flow may improve conditions in Mokelumne River channels and increase survival relative to historical levels. Conversely, reduced flow in the Sacramento River below the through-Delta intakes may degrade conditions affecting movement and reduce survival of migrants along the lower Sacramento River route. The impact on juvenile chinook salmon cannot be determined from available data and will require implementation of appropriate studies to determine the best operation of the through-Delta facility in conjunction with the isolated facility intake.

Reduced net flow in the Sacramento River channel could increase settling of striped bass eggs and larvae through increased areas of zero flow during shifts in the tidal cycle. Settling of striped bass eggs and larvae could reduce survival and adversely affect striped bass abundance.

Adverse impacts on movement of juvenile chinook salmon, striped bass, and other Delta species may be avoided and minimized by implementing monitoring programs that determine species effects and management strategies to provide suitable habitat conditions. The isolated facility and the Tyler Island intake structure (Alternative 3H) may be operated to meet species needs relative to cross-Delta flow or flow in the Sacramento River.

Outmigrating fall-run chinook salmon in the San Joaquin River would be blocked from entering Old River and would continue with San Joaquin River flow to the central Delta. Under Alternative 3, exports from the south Delta would be reduced, and net southerly flow of central Delta water (including San Joaquin River inflow) would be eliminated (15,000-cfs isolated facility) or reduced (the south-Delta barriers would increase southerly flow from the central Delta under Alternatives 3A, 3B, and 3H). Entrainment of species rearing in the central and south Delta, such as juvenile chinook salmon, delta smelt, striped bass, and splittail, would be reduced. The effects of the south-Delta barriers and the head-of-Old-River barrier on juvenile chinook salmon and other Delta species, especially in combination with reduced south-Delta exports, is unknown. An operational barrier on Old River provides the opportunity, based on the results of additional studies, to avoid significant adverse impacts and potentially provide benefits to Delta species. Barrier operations also could improve water quality and fish habitat conditions in the San Joaquin River near Stockton and in the south Delta. Closure of the barrier without adequate biological information could result in significant adverse impacts through increased entrainment losses and degradation of water quality conditions in the south-Delta channels.

Under Alternative 3I, the three unscreened intakes in the south Delta could reduce southerly flow in Old and Middle rivers; however, the unscreened intakes would be located closer to the center of distribution of many Delta species, including larval and early juvenile striped bass and delta smelt. Relative to the No Action Alternative, flow conditions in the central Delta could be similar under Alternative 3I, but flow direction in the San Joaquin River could worsen and shift the distribution of Delta species upstream. The 15,000-cfs isolated facility included in Alternative 3I provides additional opportunity to avoid impacts on movement of species in the central and south Delta.

Species Interactions

Impacts on species interaction under Alternative 3 would be similar to those described under Alternative 1. As identified under "Entrainment," predation in the isolated conveyance channels under Alternative 3I could be higher than predation levels in Clifton Court Forebay. Adverse impacts, relative to the No Action Alternative, could result from increased predation; however, the isolated diversion facility provides an opportunity to avoid increased impacts under Alternative 3I.

BAY REGION

Most CALFED actions focus on the Delta Region and affect the Bay Region through changes in the quantity and quality of Delta outflow. Some CALFED actions, including the Ecosystem Restoration and Water Quality programs, focus on restoration of functional and structural characteristics of the Bay ecosystem.

ALL ALTERNATIVES

Under all alternatives, wetlands and other lands currently protected by levees would be converted to tidally connected areas, including sloughs, tidal flats, and open-water areas. Additional high spring flow would be allowed to pass down the rivers and through the Delta without being stored, diverted, or exported. A greater proportion of the water being diverted or exported from the Bay system would be passed through fish screens, the toxicant load entering the system from industrial facilities and other sources would be substantially reduced, and a large-scale effort to control invasive non-native plant species would be undertaken.

Impacts resulting from the Water Use Efficiency Program, including water transfers in the Bay Region are similar to those discussed for the Delta Region. However, because most efficiency measures will occur in the urban sector, modifications to flow timing and return flow water quality will be minimal.

Water transfers to urban uses that divert from the Delta (Contra Costa, South Bay Aqueduct, North Bay Aqueduct) are expected to be coordinated to maximize the fishery and aquatic ecosystem benefits.

Ecosystem-Level Impacts

Flow

Under all alternatives, reservoir and diversion facilities could be reoperated to provide flows that protect and enhance the ecological functions and processes that operate in the Bay. Ecosystem Restoration Program actions that reestablish naturally occurring short-term flow increases would be implemented under all alternatives (Table 12) and require evaluation at a greater level of detail (daily) than is available for this impact assessment. Flow-related actions would result in beneficial impacts on sediment and nutrient input and movement, productivity, and salinity distribution. Impacts of short-term flow events would require evaluation prior to implementation of specific program actions.

Increased exports under Alternatives 1 and 2 and Alternatives 3A, 3B, and 3H would increase the frequency of low outflows from November through January. Reduced outflow would shift X2 upstream. Adverse impacts could include reduced habitat. Under Alternatives 3E and 3I, the frequency of low outflows from October through December would decrease, indicating increased outflow. Increased outflow would shift X2 downstream, potentially increasing habitat. The effects on simulated outflow would be small relative to existing conditions and the No Action Alternative; however, operations and diversions under all alternatives would continue to degrade outflow patterns relative to the natural condition.

When Delta outflow is relatively low (from August through October) and diversion of cross-Delta flow substantially reduces net Sacramento River flow downstream of Georgiana Slough, the resulting conditions may shift X2 farther into the Delta (Table 21). The Hood (Alternatives 2A, 2B, 2D, and Alternative 3) and Tyler Island (Alternatives 2E and 3H) intakes increase the potential to shift X2 upstream by reducing net Sacramento River flow (Table 20). The Hood diversion, because it incorporates a pumping facility, potentially would divert more of the Sacramento River flow than the Tyler Island diversion during low-flow periods. Shifting X2 farther upstream in the Delta potentially would reduce low-salinity habitat for Bay species.

Water Temperature

Water temperature conditions in the Bay Region under all alternatives would be similar to those under the No Action Alternative.

Sediment and Nutrient Input and Movement

Actions affecting sediment and nutrient input and movement under Alternative 1 primarily would be implemented in areas upstream of the Bay Region; however, restoration actions included in the Ecosystem Restoration Program may directly affect sediment and nutrient input and movement in the region. Potential actions include development and implementation of dredging guidelines, implementation of plans to reduce erosion attributable to boat wakes in sensitive areas, and restoration of aquatic and adjacent terrestrial and wetland communities.

Contaminant Input and Movement

In the Bay Region, the Water Quality Program would reduce emissions of contaminants in urban and industrial runoff and in wastewater treatment plant discharges by enforcing existing regulations and providing monetary incentives. Although contaminant input may be reduced relative to the No Action Alternative, urban and industrial growth would increase contaminant input under all alternatives relative to existing conditions (CALFED 1997c).

Contaminants in the Sacramento and San Joaquin rivers and the Delta eventually enter the Bay. Actions that address contaminant input and movement upstream of the Bay Region also would benefit the Bay ecosystem.

Productivity

Productivity would be affected by the impacts identified for the processes discussed above, including flow, and from changes in structural characteristics described below. Restoring aquatic and adjacent communities, including riparian, shallow water, and tidal marsh, would increase productivity by increasing primary production and input of organic carbon. Increased primary production results from increasing the area available to support aquatic plants, including algae and vascular plants, and increasing the density of plants in restored habitats. Increased input may result from reestablishing connections between terrestrial and aquatic habitats. Beneficial impacts on productivity upstream of the Bay Region will also provide beneficial impacts on the Bay ecosystem.

Structural Characteristics

Actions in the Ecosystem Restoration Program include restoration of aquatic and adjacent communities, including riparian, shallow water, and tidal marsh. Restoration of tidal aquatic areas, possibly several thousand acres, may result from breaching levees and flooding existing managed wetlands and from setting levees back along the existing Bay and marsh channels. Changing levee maintenance practices to allow development of natural riparian and marsh communities also would result in beneficial impacts on structural characteristics of the Bay.

Species-Specific Impacts

Beneficial and adverse impacts were based on species and life-stage needs, together with geographical and seasonal occurrence.

Habitat

The conversion of some managed wetlands to inundated tidal wetlands and open-water habitat under CALFED would markedly increase the abundance of aquatic habitat for Bay species. Under full implementation of the Ecosystem Restoration Program, the extent of tidal acreage within the Bay, especially in Suisun Marsh and other marsh areas, would increase by several thousand acres. The habitat value of newly inundated areas for Bay species would vary greatly depending on the location and morphological characteristics of the restored areas.

New spawning and rearing habitat may be provided for species resident in the Bay and Suisun Marsh, such as longfin smelt and striped bass. Anadromous species, such as chinook salmon, steelhead, and white sturgeon, also may benefit from increased abundance of juvenile rearing and adult habitat.

Relative to the No Action Alternative, the reduction in Delta outflow discussed under "Flow" above potentially could reduce habitat for species with low salinity tolerance. The small change in outflow most likely would have a minimal effect on habitat availability related to salinity distribution; however, the additional reduction in outflow would contribute to the cumulative adverse impact of reduced outflow on habitat conditions.

Water Quality

Contaminant inputs would be reduced. For this programmatic document, the specificity of information is insufficient to develop impact conclusions for individual Bay species. Reduced input of contaminants most likely would benefit all Bay species, although the pathway and magnitude of the beneficial impact cannot be determined using available information.

Entrainment

Under all alternatives, the installation of new fish screens on managed wetland and agricultural diversions under Ecosystem Restoration Program actions would reduce fish entrainment and other diversion-related mortality. Fish screens would result in beneficial impacts on juvenile and adult life stages of most Bay species relative to conditions under the No Action Alternative. Entrainment of planktonic invertebrates (native mysids and rotifers) and fish eggs and larvae would continue.

Water Surface Level

Water surface levels in the Bay Region under all alternatives would be similar to those under the No Action Alternative.

Movement

As discussed above under "Flow," reduced outflow would reduce movement of nutrients and organisms into the Bay.

Species Interactions

The Ecosystem Restoration Program includes actions that may reduce the extent of invasive non-native aquatic and riparian plants, reduce or eliminate the influx of non-native aquatic species from ship ballast water, and reduce the potential for influx of non-native aquatic plant and animal species at border crossings. The actions may decrease the adverse impacts associated with establishment of non-native species populations in the Bay, including impacts of increased competition for limited resources, predation, and disease.

Artificial Production

Targets in the Ecosystem Restoration Program include managing artificial fish propagation programs consistent with rehabilitation of naturally producing populations, conserving ecological and genetic values, achieving recovery of special-status species, and maintaining healthy populations of other species. In general, these actions would result in beneficial impacts on longfin smelt and striped bass in the Bay Region.

Harvest

Actions in the Ecosystem Restoration Program designed to reduce illegal harvest and improve sport and commercial harvest management for anadromous fish would result in increased survival of adult fish and reduced impacts on self-sustaining natural populations. Such actions include improving harvest regulations, providing additional law enforcement, developing cooperative programs to increase public awareness, and providing a means for reporting illegal harvest violations. Species likely to benefit from such actions in the Bay Region include striped bass, chinook salmon, and sturgeon.

SACRAMENTO RIVER REGION

Except for the effects of flow changes, the ecosystem and species-specific impacts described below are equally applicable to fisheries and aquatic resources in the San Joaquin River Region. Implementation of CALFED would result in beneficial impacts on fisheries and aquatic resources in the Sacramento River Region under all alternatives. More detailed and site-specific information would be required to identify impacts that may distinguish specific alternatives.

Reestablishing the floodplain/meander belt on the lower Sacramento River, restoring riparian habitat, and constructing side channels would provide thermal refuges for fish through increased riparian shading and reestablishment of natural channel configurations. Reducing levels of fine sediment input and providing adequate gravel would create and sustain quality salmonid spawning conditions. Reestablishing floodplain connections, including setting levees back, and establishing riparian communities would reactivate and maintain natural sediment transport processes, increase nutrient input into the system, and increase biological productivity.

Installing or improving fish screens at all large and some small water diversions would reduce entrainment of all representative species. Removing barriers to anadromous fish passage and installing or improving fish passage facilities at barriers would improve conditions for upstream and downstream migration of anadromous fish. Reducing inappropriate attraction flows or constructing barriers would reduce movement to areas that will not support spawning and rearing of anadromous species.

New offstream storage would increase entrainment-related losses of some juvenile chinook salmon, striped bass eggs and larvae, juvenile splittail, American shad eggs and larvae, and other species. Potentially significant adverse impacts include increased predation and increased mortality attributable to impingement and entrainment. Mitigation could include restrictions to avoid diversions during the presence of eggs and larvae, seasonal removal of predators in the vicinity of the new fish facilities, and restriction of diversions to flow conditions when vulnerability of outmigrant juvenile fish is minimized.

Preventing the influx of non-native aquatic species from ship ballast, improving hatchery practices, reducing predator habitat, and reestablishing natural habitat diversity and complexity may reduce or avoid the adverse impacts of increased competition, predation, and disease.

ALL ALTERNATIVES

Ecosystem-Level Analysis

Flow

Operations effects on river flows were determined by availability of stored water for release and diversion. Under the CALFED alternatives, the first priority for developing surface storage would be to enlarge existing dams; second and third priorities include developing offstream storage (surface reservoirs and groundwater storage) and new onstream storage, respectively. The quantity of reservoir-species habitat potentially would be increased by enlarging existing dams. Inundating stream channels would adversely affect the stream ecosystem upstream of the reservoirs. Increasing storage would enable existing reservoirs to capture additional runoff and provide the potential to further alter natural flow patterns. Developing new offstream surface storage would create new habitat for reservoir species; however, extreme water surface level fluctuations in offstream reservoirs would limit habitat value for aquatic species. If diversions to fill offstream reservoirs were timed appropriately, impacts on affected stream ecosystems would be limited. Developing new onstream storage would have the greatest adverse impact on existing stream ecosystems, converting stream communities to reservoir communities and altering natural downstream flow patterns. New onstream storage also may block passage of anadromous fish to upstream spawning and rearing habitat. For the Programmatic EIS/EIR, new offstream storage was simulated, including new storage south of the Delta and new storage off the Sacramento River.

Ecosystem Restoration Program actions that reestablish naturally occurring short-term flow increases would be implemented under all alternatives (Table 12) and require evaluation at a greater level of detail than is available for this impact assessment. The flow-related actions would benefit sediment and nutrient input and movement, productivity, and channel maintenance. Impacts of short-term flow events would require evaluation prior to implementation of specific program actions.

Impacts resulting from the Water Use Efficiency Program, including water transfers in the Sacramento River and San Joaquin River Regions are similar to those discussed for the Delta Region.

For Alternatives 1A and 1B, flow in the Sacramento River and its tributaries would be the same as flow under the No Action Alternative. Alternative 1C includes new storage and reoperation of existing reservoirs to meet downstream needs and requirements. Under Alternative 1C, operations with new storage would increase flow primarily during August and September but also during May. The increase in flow is attributable to release from new storage and would affect the Sacramento River downstream of the discharge point—Red Bluff. Because of the timing of storage discharge, the additional flow generally would increase the total river flow above the natural level. Discharge from new storage during May would increase total river flow toward a natural condition and could benefit ecosystem processes, for example, sediment movement and input, and channel maintenance.

In the American River under Alternative 1, the simulated frequency of low flow is reduced in March, indicating increased flow. Additional flow in March would increase the total toward a natural condition and potentially benefit ecosystem processes. Under Alternative 1C, simulated operations of Folsom Reservoir in conjunction with new offstream storage on the Sacramento River would increase flow during September and reduce flow in October. The Feather River would experience similar flow changes.

Overall, flow changes in the Sacramento River and its tributaries would be minimal relative to flow under existing conditions and the No Action Alternative. Compared to natural flow conditions, reduced spring flow and increased summer and early fall flow would continue. Flow changes described for Alternatives 1A and 1B also would occur under Alternatives 2A and 3A. Flow changes under Alternatives 2B, 2E, 3B, 3E, 3H, and 3I are represented by the changes described for Alternative 1C.

Water Temperature

Several CALFED actions under all alternatives could affect water temperature in the Sacramento River basin. Water management modifications, including operational changes resulting from the purchase of water from willing sellers, may increase the ability to release appropriate instream flows for downstream temperature management.

Adding new storage facilities under Alternative 1C may further increase the ability to release water for maintenance of suitable stream temperatures. Enlarging existing dams may increase carryover storage and water available to manage temperature for downstream needs. Discharge from new offstream or onstream storage reservoirs may alter water temperature in downstream reaches, depending on the reservoir configuration and storage patterns. New storage also would provide the opportunity to manage temperature through water transfers and reoperation of existing reservoirs. More site-specific information will be needed to evaluate impacts on water temperature. Alternatives 2B, 2E, 3B, 3E, 3H, and 3I would have similar storage and temperature management capability. Evaluation of flow- and storage-related water temperature effects will require more detailed site-specific and short-term information.

Restoration actions in the Ecosystem Restoration Program under all alternatives could improve water temperature conditions. Restoration actions include reestablishing the floodplain/meander belt on the lower Sacramento River, making other channel modifications, restoring riparian habitat, and constructing side channels to provide thermal refuges for fish. All actions could improve water temperature conditions in the Sacramento River basin through increased riparian shading and natural channel configurations.

Sediment and Nutrient Input and Movement

The Ecosystem Restoration Program implemented under all alternatives includes actions to restore sediment deposition, maintain low levels of fine sediment input, provide adequate gravel input to sustain quality salmonid spawning conditions, redesign and reconstruct flood control systems to restore floodplain connections, reactivate and maintain natural sediment transport processes, and limit erosion by improving land use practices. Ecosystem Restoration Program actions would restore natural sources of sediment and nutrient input and benefit stream ecosystems in the Sacramento River basin. As discussed under "Flows," flow conditions would be similar to those under existing conditions and the No Action Alternative. Flow conditions affecting sediment and nutrient input and movement would not change substantially under any alternative.

Productivity

Under all alternatives, restoration actions in the Sacramento River basin, such as reestablishing the floodplain and meander belt on the lower mainstem river and restoring channels and riparian habitat, would increase natural sediment input and movement processes, increase nutrient input into the system, and increase biological productivity. Restoring the floodplain and floodplain processes would increase the nutrient and sediment flow from terrestrial zones to the aquatic ecosystem. Meander zones would increase the interface between terrestrial and aquatic zones. Restoring riparian habitat would increase the input of organic carbon in the form of leaf drop and woody debris, increase the input of terrestrial invertebrates into the stream system, and increase structural diversity.

Actions included in the Water Quality Program also would increase biological productivity in the Sacramento River basin. Reducing the input of contaminants in the basin would improve primary and secondary productivity through reduced toxic effects on aquatic organisms.

Contaminant Input and Movement

Actions in the Water Quality Program would decrease the total pollutant load into the Bay-Delta system. In the Sacramento River basin, action strategies address reducing heavy metals emissions by controlling the source and treating mine drainage, reducing emissions of contaminants in urban and industrial runoff and in wastewater treatment plant discharges by enforcing existing regulations and providing monetary incentives, and reducing emissions of contaminants in agricultural surface runoff. The overall effect of the program would be a decrease in adverse effects of contaminants on the aquatic ecosystem in the Sacramento River basin. A variety of ecosystem functions would be restored to a more natural state as a result of the reduction in contaminant levels. Although contaminant input may be reduced relative to the No Action Alternative, urban and industrial growth would increase contaminant input under all alternatives relative to existing conditions (CALFED 1997c).

Structural Characteristics

More natural surface features associated with the floodplain and meander belts would be restored by setting levees back. Additionally, restoring natural surface features would allow development of channel complexity.

Species-Specific Analysis

Habitat

Several actions in the Ecosystem Restoration Program would increase habitat for representative species in the Sacramento River basin. Actions to improve sediment input and transport and adding gravel to specific stream reaches would improve spawning and rearing habitat for chinook salmon and steelhead. Reestablishing the floodplain/meander belt on the lower Sacramento River, modifying channels, and restoring riparian habitat would improve habitat for all representative species.

New reservoir storage could create additional habitat for reservoir species, including largemouth bass and rainbow trout.

Water Quality

Changes in water temperature and contaminant input and movement described in the ecosystem analysis would likely benefit all species. Adverse water temperature conditions for chinook salmon and steelhead exist under the No Action Alternative and would continue to exist under Alternative 1. Adverse water temperature conditions in the mainstem Sacramento River for oversummering winter-run chinook salmon are of particular concern. Changes in the stream temperature regime could improve habitat for migration, spawning, and rearing of chinook salmon and steelhead. Reoperation of reservoirs in response to implementation of CALFED actions potentially degrades water quality conditions and increases spawning and rearing mortality for chinook salmon and steelhead trout. Identification and analysis of the impacts of water temperature changes attributable to implementation of CALFED will require detailed evaluation of specific projects.

Entrainment

Ecosystem Restoration Program actions in the Sacramento River basin include installing or improving fish screens at all large and some small water diversions. Actions also include reducing diversion volumes, modifying operations, or consolidating diversions to minimize screening needs. Effective screening would reduce entrainment of all representative species in the mainstem river and tributaries. Target species for entrainment reduction include chinook salmon (all races) and steelhead.

The diversion to fill new offstream storage in Alternatives 1C, 2B, 2D, 2E, 3B, 3E, 3H, and 3I could increase entrainment losses of some species. Potentially significant adverse impacts include increased predation associated with the fish screen facility; increased losses attributable to fish screen inefficiency; and increased losses of eggs and larvae—for example, for striped bass, splittail, and American shad. Mitigation could include restrictions to avoid diversions during the presence of eggs and larvae, seasonal removal of predators in the vicinity of the new fish facilities, and restriction of diversions to flow conditions when vulnerability of outmigrant juvenile fish is minimal.

Water Surface Level

Ecosystem Restoration Program actions that reduce and control short-term flow and water surface fluctuation would be implemented under all alternatives (Table 12) and require evaluation at a greater level of detail than is available for this impact assessment. Impacts of short-term flow events would require evaluation prior to implementation of specific program actions. Reduced short-term fluctuation in water-surface level would reduce habitat loss, interruption of spawning, desiccation of eggs, increased predation, and stranding of juvenile fish. Species benefitting from reduced short-term flow fluctuations include all representative species, but the greatest benefit would be to chinook salmon and steelhead.

Simulated monthly reservoir operations are similar under the No Action Alternative and all alternatives. Effects on the success of largemouth bass spawning, which occurs in shallow water along the shoreline of reservoirs, would be similar to effects under the No Action Alternative.

Movement

Flow and structural changes resulting from Ecosystem Restoration Program actions and implementation of storage and conveyance components under all alternatives may improve conditions for upstream and downstream migration of anadromous fish in the Sacramento River basin. Species likely to benefit include chinook salmon, steelhead, sturgeon, striped bass, and American shad.

Ecosystem Restoration Program actions include removing barriers to anadromous fish passage and installing or improving fish passage facilities at barriers. These actions would improve conditions for upstream and downstream migration of anadromous fish. Species affected in the Sacramento River basin would include chinook salmon (all races), steelhead, sturgeon, and American shad.

Ecosystem Restoration Program actions also would reduce fish straying by modifying drainage outfalls, constructing weirs or screens, or reducing inappropriate attraction flows to keep fish out of areas that will not support spawning and rearing. These actions would reduce straying of upstream migrating adult chinook salmon and steelhead.

As described under "Flow," simulated flow conditions affecting movement would be similar for the No Action Alternative and Alternatives 1A, 1B, 2A, and 3A. Under Alternatives 1C, 2B, 2E, 3B, 3E, 3H, and 3I, operations with new storage would increase Sacramento River flow primarily during August and September but also during May. In the American River, the frequency of simulated low flow is reduced in March, indicating increased flow. Operation of Folsom Reservoir in conjunction with new offstream storage on the Sacramento River would increase simulated flow during September and reduce flow in October. Similar flow changes would occur on the Feather River. Increased flow during March and May would improve conditions for winter-, spring- and fall-run juvenile chinook salmon outmigration. Increased flow during August and September could improve conditions for adult fall-run chinook salmon upstream migration. Reduced flow in October could adversely affect adult migration. Flow changes simulated for the Sacramento River system would be minimal relative to flow under existing conditions and the No Action Alternative. Compared to natural flow conditions, reduced spring flow and increased summer and early fall flow would continue to occur. Evaluation of short-term flow changes that may occur with implementation of the Ecosystem Restoration Program require evaluation at a greater level of detail than is available for this impact assessment. Impacts of short-term flow events will require evaluation prior to implementation of specific program actions.

Species Interactions

In the Sacramento River, diversion structures at Red Bluff Diversion Dam, Glenn-Colusa Irrigation District's Hamilton City Pumping Plant, and other locations have created conditions that increase predation losses of juvenile chinook salmon and other species. The Ecosystem Restoration Program includes measures to modify project operations or restructure diversion facilities to eliminate or reduce the vulnerability of juvenile chinook salmon to predation.

The Ecosystem Restoration Program includes actions that may reduce the influx of non-native aquatic species from ship ballast water and directly control populations of non-native species. The actions may decrease the adverse impacts associated with establishment of non-native species in the Sacramento River, including increased competition, predation, and disease. Other Ecosystem Restoration Program actions that may reduce predation and competition in the Delta include improved hatchery practices, reduced predator habitat, improved fish passage at barriers, and restored habitat diversity and complexity for native species.

Artificial Production

Targets for artificial production in the Ecosystem Restoration Program include managing fish propagation programs consistent with rehabilitating naturally reproducing fish populations, conserving ecological and genetic values, implementing successful recovery programs for special-status species, and maintaining healthy populations of other species. These actions would result in beneficial impacts on all representative species in the Sacramento River basin. Propagation programs for steelhead and chinook salmon in the Sacramento River basin are likely to be affected by these targets.

Harvest

Actions in the Ecosystem Restoration Program designed to reduce illegal harvest and improve harvest management for anadromous fish would result in increased survival of adult fish and reduced impacts on self-sustaining natural populations. Such actions include improving harvest regulations, providing additional law enforcement, and developing a strong public education program. Species likely to benefit from such actions in the Sacramento River Region include striped bass, sturgeon, chinook salmon, and steelhead.

SAN JOAQUIN RIVER REGION

Except for flow changes, ecosystem and species-specific impacts identified for the Sacramento River Region are equally applicable to the San Joaquin River Region (see the preceding section). Simulated flows for the San Joaquin River and major tributary streams (the Mokelumne, Stanislaus, Tuolumne, and Merced rivers) indicate minimal differences between flow conditions for the No Action Alternative and all alternatives. Compared to natural flow conditions, reduced spring and early summer flow and increased early fall flow would continue to occur under all alternatives. Cumulative adverse impacts that would continue under the alternatives include reduced support of essential ecosystem processes, such as sediment and nutrient input and movement, and insufficient flow variability to maintain historical biodiversity.

Ecosystem Restoration Program actions that reestablish naturally occurring short-term flow increases would be implemented under all alternatives (Table 12) and require evaluation at a greater level of detail than is available for this impact assessment. The flow-related actions would have beneficial impacts on sediment and nutrient input and movement, productivity, and channel maintenance. Impacts of short-term flow events will require evaluation prior to implementation of specific program actions.

Actions that reduce entrainment of striped bass in SWP and CVP exports (see Delta Region) could reduce recruitment of striped bass to San Luis Reservoir, adversely affecting sport fishing. Fisheries in other reservoirs would be minimally affected.

Impacts resulting from the Water Use Efficiency Program, including water transfers in the Sacramento River and San Joaquin River Regions are similar to those discussed for the Delta Region.

SWP AND CVP SERVICE AREAS OUTSIDE THE CENTRAL VALLEY

Implementation of CALFED alternatives would most likely result in minimal impacts on fisheries and aquatic resources in streams, reservoirs, and estuaries in SWP and CVP Service Areas Outside the Central Valley. Although the volume and quality of water exported may increase, organisms transported with the water and the destination of the water would be the same as under the No Action Alternative. Actions that address introduction of non-native species to the Bay-Delta river system would limit introduction to areas receiving SWP and CVP water.

Operations rules and demands would be the same under the No Action Alternative and all alternatives and would limit the ability to change patterns of delivery to SWP and CVP service areas. Additional water delivered to SWP and CVP service areas may induce municipal, industrial, or agricultural development and affect aquatic resources. Impacts require detailed site-specific information on delivery areas, potential for increased development, and vulnerable aquatic resources.

Since water use efficiency improvements will help extend current water supplies to meet future water demands (resulting from population increases), there could be a beneficial impact to the fisheries and aquatic ecosystems, when compared to the No Action Alternative. Under the No Action Alternative, the potential exists for Delta diversions to increase. Water use efficiency measures can reduce or eliminate the need for future increases in Delta diversion.

Comparison of CALFED Alternatives to Existing Conditions

Relative to existing conditions, impacts of all CALFED alternatives, including all Configurations, would be similar to the impacts described relative to the No Action Alternative. In addition, the increase in SWP and CVP export from the south Delta relative to existing conditions would be greater than the increase relative to the No Action Alternative. Under Alternatives 1 and 2 and Alternative 3I, increased export would increase entrainment loss of organisms and nutrients, increase entrainment of fish species, and increase net reverse flow in Old and Middle rivers, potentially reducing productivity and disrupting migration of fish species.

In all regions and under all alternatives, increased input of urban and industrial contaminants would increase stress on biological processes, such as organism growth and fecundity and organism susceptibility to disease, and would have an adverse effect on aquatic species survival.

Under all alternatives, changes in the allocation of the dedicated water under the CVPIA, in combination with Ecosystem Restoration Program actions, would provide flow to improve habitat conditions, benefiting spawning, rearing, and migration for chinook salmon, striped bass, and other species in the Sacramento and San Joaquin River basins. Revised FERC and other agreements would alter flow releases on the Yuba and Tuolumne rivers and may benefit aquatic species, including chinook salmon. The Shasta temperature control structure would provide the opportunity to improve water temperature conditions in the Sacramento River. The additional flexibility for water temperature control would benefit all runs of chinook salmon and steelhead spawning and rearing in the Sacramento River. Ongoing clean-up programs, in combination with the CALFED Water Quality Program, are expected to alleviate future mine discharge problems and benefit aquatic species in the Sacramento and San Joaquin River basins.

For SWP and CVP Service Areas Outside the Central Valley, additional water supply available under all alternatives may increase urban and industrial development and cause additional loss of aquatic areas and degradation of the aquatic environment through increased contaminant input, increased incidence of human-caused disturbance, and other factors. The MWD Eastside Reservoir Project will create additional habitat for reservoir species. The Coastal Aqueduct and the MWD Inland Feeder Project transport Delta water to streams, reservoirs, and estuaries outside the Central Valley. Introduction and establishment of non-native species in areas currently isolated from the Central Valley may result in adverse impacts on native species, including increased competition for resources, predation, and disease.

MITIGATION STRATEGIES

Mitigations are proposed as strategies in this programmatic document and are conceptual in nature. Final mitigations would need to be approved by responsible agencies as specific projects are approved by subsequent environmental review.

The impact assessment for fisheries and the aquatic ecosystem is based on available information. Detailed information on CALFED actions or responses to the actions are sometimes unavailable. Because of the uncertain results of actions affecting the ecosystem, CALFED actions would be implemented through adaptive management. Adaptive management includes identification of indicators of ecosystem health; phased implementation of substantial project actions, comprehensive monitoring of the indicators; and a commitment to remedial actions necessary to avoid, minimize, or mitigate immediate and future adverse impacts of project actions on ecosystem health. The following section summarizes potential mitigation measures by impact. Mitigation measures would be part of an adaptive management program implemented to achieve the intent of the CALFED Bay-Delta Program and the major ecosystem-quality objectives.

Additional CVP and SWP exports from the south-Delta would increase entrainment loss and increase net reverse flow in Old and Middle rivers, potentially reducing productivity and disrupting migration of fish species. Impacts of increased export could be minimized by shifting the timing of diversions to periods when species are less vulnerable, such as when the proportion of the population in the vicinity of the diversion is small or when individuals are relatively large and fish facilities are more efficient. Timing could be dependent on time of year (such as August to October) or restricted to periods of relatively high inflow. Impacts of increased export from the south-Delta could be avoided through change in location of the diversion point, similar to conveyance components included in Alternative 3.

The screened through-Delta facility and isolated facility intakes would cause entrainment-related mortality for Sacramento River fish. The significance of the impact is uncertain. A monitoring program would be implemented to determine the mortality attributable to the fish screening facility. Mortality thresholds would be established through consultation with USFWS, NMFS, and DFG. Actions would be

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implemented to avoid mortality in excess of the mortality thresholds and could include:

- Improved facility design;
- Implementation of predator removal programs;
- Change in location of the diversion point (for example, revert to the conditions under the No Action Alternative); and
- Shift in timing of diversion to periods when species are less vulnerable, such as when the proportion of the population in the vicinity of the diversion is small or when individuals are relatively large and fish facilities are more efficient.

Through-Delta facilities would increase cross-Delta flow, potentially reducing productivity and increasing mortality of fish. The significance of the impact is uncertain. A monitoring program would be implemented to determine the mortality attributable to movement into the Mokelumne River channels. Mortality thresholds would be established through consultation with USFWS, NMFS, and DFG. Actions would be implemented to avoid mortality in excess of the mortality thresholds and could include:

- Change in location of the diversion point (for example, revert to the conditions under the No Action Alternative); and
- Shift in timing of diversions to periods when the proportion of the population drawn into the Mokelumne River channels is small.

Through-Delta facilities and isolated facilities would increase the proportion of flow and fish drawn off the Sacramento River and into Georgiana Slough, reducing survival of chinook salmon and steelhead. Mitigation is similar to that described for the preceding impact.

Through-Delta and isolated facilities would reduce Sacramento River flow and shift X2 upstream, potentially reducing survival and habitat quantity and quality for striped bass, delta smelt, and other species. The significance of the impact is uncertain. A monitoring program would be implemented to determine the shift in X2 attributable to reduced net Sacramento River flow past Rio Vista and effects on distribution of Delta species (such as delta smelt and striped bass). Monitoring would also determine the change in species mortality attributable to reduced Sacramento River flow, focusing primarily on chinook salmon and striped bass. Actions would be implemented to avoid mortality in excess of specific mortality thresholds and to avoid shifts in distribution that may be detrimental to species survival. Mitigation actions could include:

- Change in location of diversion point (for example, revert to the conditions under the No Action Alternative); and
- Shift in timing of diversions to periods when the proportion of the population affected is small.

Adult fish bound for the Sacramento River would be attracted by cross-Delta flow into the Mokelumne River channels, and their return to the Sacramento River would be blocked by fish screens. Impacts of through-Delta facility screens on adult migration could be minimized by shifting the timing of diversions to periods when potentially affected species are least abundant. Based on monitoring to determine the response of adult fish to migration cues, through-Delta diversions could be contingent on the magnitude of Sacramento River flow and the relationship to attraction of adult fish along specific migration routes through the Delta. Impacts of attraction also could be minimized through design that facilitates movement of adult fish past the screened facility, including construction of fish bypasses or trapping and transport of adult fish.

New isolated facility intakes along the San Joaquin River would increase entrainment loss, potentially reducing productivity and disrupting migration of fish species. Diversion from new isolated facility intakes along the San Joaquin River would be contingent on development of an intensive monitoring program that conclusively indicates beneficial change in potential entrainment, fish distribution, and flow conditions. If specific criteria are not met or cannot be substantiated, exports would occur from facilities consistent with the No Action Alternative or from an isolated facility diversion point off the Sacramento River. Diversion from the isolated facility diversion point off the Sacramento River would require implementation of mitigation identified above for isolated facility impacts.

Operation of an intertie between the existing CVP intake and Clifton Court Forebay may increase entrainment of organisms from the south-Delta. Exports with operation of the intertie would be contingent on the development of an intensive monitoring program that conclusively indicates beneficial changes in potential entrainment, fish distribution, and flow conditions. If specific criteria are not met or cannot be substantiated, exports would occur from facilities consistent with the No Action Alternative.

South-Delta barriers potentially reduce connectivity to other Delta channels, reduce water quality conditions, and increase loss of nutrients and organisms from south-Delta channels. Mitigation could include restoration of equivalent areas through setback levees and island flooding in the south- and central-Delta. Operation of barriers would be contingent on development of an intensive monitoring program that conclusively indicates beneficial change in potential entrainment, fish distribution, water quality, and flow conditions. If specific criteria are not met or cannot be substantiated, the barriers would be operated to provide conditions consistent with the No Action Alternative.

Construction of a through-Delta facility would modify and destroy spawning and rearing habitat for spittail, delta smelt, and other Delta species. Mitigation could include restoration of equivalent areas through setback levees and island flooding in the east- and north-Delta. Reconstruction of aquatic areas associated with Storage and Conveyance under Variation 2D may mitigate this impact. Aquatic communities would need to meet specific restoration objectives. A monitoring program would be implemented to determine sufficiency of mitigation actions and the need for additional remedial actions.

Diversion to fill new off-stream reservoirs could increase entrainment loss of juvenile fish. Impacts could be minimized by restricting the timing of diversions to periods when species are less vulnerable, such as when the proportion of the population in the vicinity of the diversion is small or when individuals are relatively large and fish facilities are more efficient. Timing could be dependent on time of year (such as August to October) or restricted to periods of relatively high river flow. Impacts could be avoided through change in location of the diversion point. Diversions could be directly from the most upstream reservoirs, avoiding entrainment effects on anadromous species.

Reoperation of upstream reservoirs to meet downstream flow needs potentially increases water temperature, increasing spawning and rearing mortality for chinook salmon and steelhead. Impacts could be avoided or minimized through implementation of reservoir operations criteria that maintain sufficient carry-over storage and streamflow to meet water temperature needs of chinook salmon and steelhead. Related actions could include water transfers, increased water use efficiency, and construction of water temperature control structures.

POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

Most of the impacts identified in this assessment can be avoided, minimized, or mitigated. Some impacts, however, irreversibly affect ecosystem structure and species habitat. Construction and operation of new reservoirs, depending on location, could eliminate existing spawning and rearing habitat. Loss of aquatic species habitat, particularly anadromous salmonid habitat, is a significant adverse impact that cannot be mitigated. Reservoir sites should be constructed in areas not currently supporting spawning and rearing habitat for anadromous species.

Actions that destroy or modify existing ecosystem structure and species habitat include breach, setback, or removal of levees and hard bank protection; establishment of riparian, wetland, and aquatic plant communities; and addition of gravel to selected stream reaches and construction of through-Delta facilities, south-Delta barriers, diversion facilities, and other channel "improvement." Although re-establishment of ecosystem structure and species habitat is assumed, the value of enhanced or re-established habitat to a species will vary greatly, depending on location and morphological characteristics. If re-established habitats are located close to export facilities, are isolated from existing habitat, lack components critical to species needs, or provide habitat for competing or predatory species, the habitat value may be minimal.

Incomplete knowledge of species needs and unpredictable responses to restoration actions may adversely affect some species and cause unavoidable impacts. Avoiding habitat loss depends on developing knowledge of species needs and understanding of the project actions. Avoiding adverse impacts of habitat loss can be assured only through implementation programs that include adaptive management.

In addition to actions directly affecting ecosystem structure and species habitat, additional water supply may increase urban and industrial development, and cause additional loss and degradation of the aquatic environment through increased contaminant input, increased incidence of human-caused disturbance, and other factors. The adverse impacts may be unavoidable because they are indirect and often not site specific. Development of mitigation for growth-inducing factors requires information currently not available.

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